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SMITHSONIAN INSTITUTION
UNITED STATES NATIONAL MUSEUM
Bulletin 109

CONTRIBUTIONS TO A HISTORY OF AMERICAN STATE GEOLOGICAL AND NATURAL HISTORY SURVEYS

EDITED AND COMPILED BY

GEORGE P. MERRILL
Head Curator of Geology, United States National Museum

WASHINGTON
GOVERNMENT PRINTING OFFICE
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ADVERTISEMENT.

The scientific publications of the United States National Museum consist of two series, the *Proceedings* and the *Bulletins*.

The *Proceedings*, the first volume of which was issued in 1878, are intended primarily as a medium for the publication of original, and usually brief, papers based on the collections of the National Museum, presenting newly acquired facts in zoology, geology, and anthropology, including descriptions of new forms of animals and revisions of limited groups. One or two volumes are issued annually and distributed to libraries and scientific organizations. A limited number of copies of each paper, in pamphlet form, is distributed to specialists and others interested in the different subjects as soon as printed. The dates of publication are recorded in the tables of contents of the volumes.

The *Bulletins*, the first of which was issued in 1875, consist of a series of separate publications comprising chiefly monographs of large zoological groups and other general systematic treatises (occasionally in several volumes), faunal works, reports of expeditions, and catalogues of type-specimens, special collections, etc. The majority of the volumes are octavos, but a quarto size has been adopted in a few instances in which large plates were regarded as indispensable.

Since 1902 a series of octavo volumes containing papers relating to the botanical collections of the Museum, and known as the *Contributions from the National Herbarium*, has been published as bulletins.

The present work forms No. 109 of the *Bulletin* series.

William deC. Ravenel,
Administrative Assistant to the Secretary,
In charge of the United States National Museum.

Washington, D. C., *March 15, 1920.*

PREFACE.

A work along the lines of the one here presented was projected and begun by the Director of the United States Geological Survey in 1885. In connection therewith a circular, bearing date of April 10 of that year, was issued, from which is made the following abstract:

> Recent inquiries by the United States Government concerning foreign scientific surveys have demonstrated the desirability of recording in permanent and accessible form all available data relating to the organization, administration, cost, and material results of geologic, geodetic, geographic, mineralogic, agricultural, natural history, and other scientific surveys officially instituted at various times by the several States of the Union.
>
> The necessity for immediate action in the collection of such data is manifest, since much valuable information—particularly details of administration and cost—has never been published, but exists only in the memory of men, in private records, and in public records liable to become destroyed or forgotten with the decadence of the present generation.
>
> It is accordingly proposed by the United States Geological Survey to collect material for a History of American State Surveys, with a view of publishing it, if possible, during the present year.

It was the original intention, in order that the plan might be carried out most expeditiously and accurately, to invite geologists or others especially familiar with the scientific surveys of particular States, to prepare detailed histories in such form that after having served their purpose as material for the general history, they might be published individually under such conditions as the authors might elect. A considerable number of the histories were thus prepared, as is noted later, and a few published. What led to the abandonment of the plan is not known to the present writer. A study of the circular and the manuscripts submitted in response thereto, leads one to infer, however, that the outline was too detailed and comprehensive, and in but few instances was it possible even for those who actually participated in the work to furnish the information desired. The result was that the histories were of unequal length and value, surveys of the least importance often being made to appear as of first magnitude. Concerning what was unquestionably the most important of all the surveys undertaken, not a line was furnished.

It was while engaged in the final revision of his Contributions to a History of American Geology,[1] that the present writer became first aware of the existence of these manuscripts. He thereupon applied to the Director of the Survey for permission to refer to them, and, if desirable, utilize any information contained therein. This permission was granted, as shown by the following letter:

---

[1] Annual Report U. S. National Museum, 1904 (1906).

Department of the Interior,
United States Geological Survey,
Washington, D. C., October 28, 1902.

Dr. Geo. P. Merrill,
U. S. National Museum,
Washington, D. C.

Dear Sir: In accordance with your request of recent date I send you herewith the manuscripts relating to the history of official scientific surveys collected by the survey some years since. These manuscripts contain a large amount of valuable historical data, much of which it would be difficult to replace.

* * * * * * *

You are at liberty to use any material which they contain in any way that you see fit.

I should be glad to have you consider the preparation of a history of official scientific surveys in the United States for publication by this Survey, using the material now in hand and such other material as you may be able to obtain in cooperation with the Survey by correspondence and otherwise.

Very respectfully,

(Signed) Chas. D. Walcott,
Director.

The proposition made in the final clause of the above was agreed to with a verbal understanding that the work should receive attention only when official and other more pressing duties permitted.

Shortly after the withdrawal of Director Walcott from the Survey the matter was brought to the attention of Director George O. Smith, with the results given in the following letter:

Department of the Interior,
United States Geological Survey,
Washington, D. C., February 6, 1908.

Dr. George P. Merrill,
Head Curator of Geology,
Smithsonian Institution.

My Dear Doctor Merrill: In reply to your inquiry of November 16 on the subject of the manuscript history of the State surveys, further consideration has simply confirmed my first impression that this material should be turned over to you for publication. * * * I note that Director Walcott in 1902 stated that you were at liberty to use the material in any way that you saw fit, and I can do no less than confirm his action in giving you a free hand in the matter. In fact, however much I might desire to see this work published under Survey auspices, the present superabundance of material awaiting publication makes it impossible for me to use any of the printing appropriation for a publication that is not directly connected with our current work.

* * * * * * *

Cordially, yours,

(Signed) Geo. Otis Smith,
Director.

With this much by way of explanation the present writer feels that no apologies are necessary. The compilation has been carried on at odd times, the manuscript in some instances lying a full year without being touched. Naturally, much desired information is wholly out of reach. The leading participants in these surveys have for the most part gone over to the majority, and the written and published results are lacking in many interesting particulars. Undoubtedly a search through State records would have brought to light more data regarding expenditures, but no funds have been available for the purpose, and the utility of greater detail is perhaps questionable. It has been the writer's custom, in all cases where it was necessary or seemed desirable, to send the manuscript to those now in charge of surveys in the individual States for such information as was available. He takes this opportunity to acknowledge his indebtedness and express his thanks for the aid thus afforded.

April, 1907.

Supplemental Note.—It was the original intention to bring this history down to a date not later than 1885. In but few instances has this limit been passed. Any seeming desirability of so doing has been anticipated by the publication of Bulletin 465 of the United States Geological Survey in 1911.

G. P. M.

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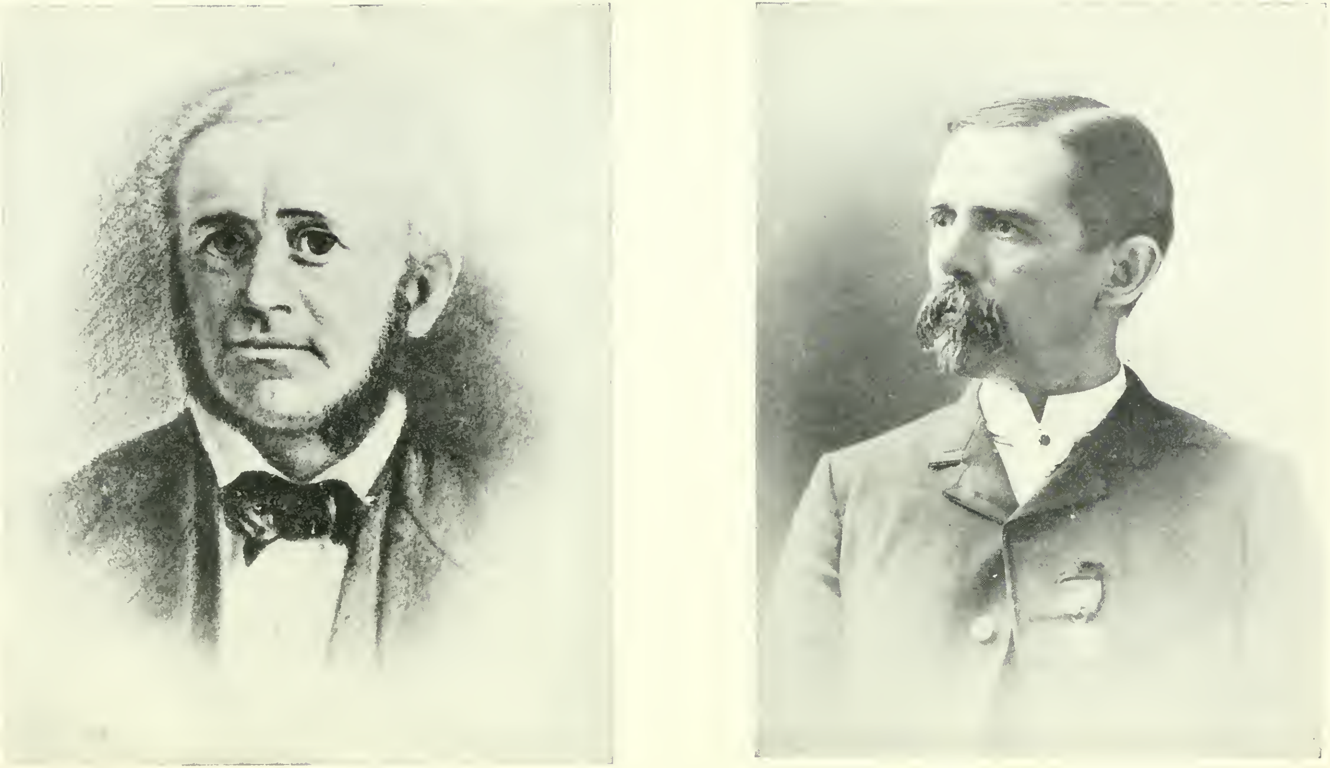

MICHAEL TUOMEY, 1848-57

EUGENE ALLEN SMITH, SINCE 1873

STATE GEOLOGISTS OF ALABAMA.

CONTRIBUTIONS TO A HISTORY OF AMERICAN STATE GEOLOGICAL AND NATURAL HISTORY SURVEYS

EDITED AND COMPILED BY

GEORGE P. MERRILL

Head Curator of Geology, United States National Museum

ALABAMA.[1]

FIRST GEOLOGICAL SURVEY UNDER MICHAEL TUOMEY, 1848–1856.

Organization.—Upon the appointment in 1847 of Michael Tuomey to the professorship of geology in the University of Alabama it was made a part of his duty to spend a portion of his time, not exceeding four months of each year, in making such explorations in connection with his department as the trustees might consider to be for the advantage of the State. Such extracts from his reports to the trustees as were considered of general interest were published from time to time in the newspapers of the city of Tuscaloosa.

In January, 1848, the State legislature made recognition of these efforts by appointing Professor Tuomey state geologist. The following is the text of the act:

> Whereas Michael Tuomey, professor of mineralogy, geology, and agricultural chemistry, in the University of Alabama, is required by an ordinance of the board of trustees of the university to devote a portion of his time and labor in making geological explorations and examining into the natural resources of the State;
>
> And whereas it would be both interesting and useful to the general assembly and to the people to examine the reports which he may make from time to time: Therefore,
>
> *Be it resolved by the Senate and House of Representatives of Alabama, in General Assembly convened,* That Michael Tuomey, professor of geology, etc., in the University of Alabama, be, and he is hereby, appointed State geologist.
>
> *Be it further resolved,* That said State geologist be, and he is hereby, required to lay before the general assembly of the State, at its biennial sessions, and as often as from time to time may be thought expedient, a full report of his geological surveys and explorations, and his examinations into the mineral and other natural resources of this State.

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[1] See also Geological Surveys in Alabama, by Prof. E. A. Smith, Journal of Geology, vol. 2, No. 3, 1894, pp. 275–287.

Thus was begun the first geological survey of Alabama. Professor Toumey's first report, a biennial, was presented to the legislature in 1849, and printed in 1850. The geological map prepared was not, however, ready for distribution with the report and was issued separately. Professor Tuomey continued his explorations, at the expense of the University, until 1850, the State having made no appropriations for the work. In 1854 this defect was remedied through the passage of the following:

> An act to provide for a geological and agricultural survey of the State.
>
> SECTION 1. *Be it enacted by the Senate and House of Representatives of the State of Alabama, in General Assembly convened*, That the governor is hereby authorized to appoint, as soon as possible, a State geologist, who shall perform the duties herein prescribed, and during the period of his service shall hold no other office in this State.
>
> SEC. 2. *Be it further enacted*, That said State geologist shall as speedily as possible make a complete and thorough geological survey of the State, so as to determine accurately the quality and characteristics of its soil and their adaptation to agricultural purposes, its mineral resources, their location and the best means for their development; its water powers and capacities; and generally everything relating to the geological and agricultural character of the State.
>
> SEC. 3. *Be it further enacted*, That said State geologist shall make a full report of his surveys and explorations into the mineral and other natural resources of the State, accompanied by illustrative maps, charts, and drawings, to the next session of the general assembly, and the said report shall be the entire and exclusive property of the State.
>
> SEC. 4. *Be it further enacted*, That said State geologist, for the performance of said services, shall receive an annual salary of $2,500, to be paid to him quarterly after his appointment, and the further sum of $10,000 is set apart and appropriated to aid the said State geologist in the performance of his duties by employing assistants and defraying the incidental expenses of his office, to be drawn for by him as needed, and his vouchers for all expenditures made from this fund shall be filed with the comptroller, to be laid before the general assembly.
>
> SEC. 5. *And be it further enacted*, That in the event of a vacancy of the office of State geologist occurring from any cause before the completion of the survey the governor is authorized and required to appoint some suitable person to fill the place.
>
> Approved, February 3, 1854.

Personnel.—Under this law Professor Tuomey was again appointed State geologist (by Governor Winston), and resigned from the university in order to devote his whole time to the survey. During the following two years he, however, according to Prof. E. A. Smith, retained his office rooms at the university and delivered lectures to some of the classes. He was assisted by Prof. E. Q. Thornton, O. M. Lieber, and others, and in 1855, Prof. J. W. Mallet was appointed chemist to the survey. The results of the labors of Professor Tuomey and his assistants were brought together by him in a report submitted to the legislature in November, 1855. This, owing largely to the negligence of the State printer, was not published until more than two years later.

The appropriations being exhausted, Professor Tuomey resumed his work at the university in 1856, though with the intention of devoting his leisure time to the survey as before. His work was unfortunately cut short by his death, which took place on March 30, 1857. After his death Dr. J. W. Mallet undertook the task of editing and bringing out the long-delayed report. It was found that part of the manuscript was missing, some of it was incomplete, and thus a large amount of valuable material was lost to the State and to science. In September, 1858, the report, the second biennial, appeared, accompanied by another map of the State more detailed than the first. The survey was discontinued after Professor Tuomey's death.

Expenses.—By law the salary of the State geologist was fixed at $2,500 a year, and an appropriation of $10,000 was made for assistance and incidental expenses, thus bringing the total cost of the survey, during the two years of continuation after the passage of the act, up to $15,000.

SECOND GEOLOGICAL SURVEY UNDER EUGENE A. SMITH, 1873–1882.

Organization.—Upon the reorganization of the University of Alabama in 1871 the board of regents again took the initiative in reestablishing the survey by requiring the professor of geology to devote as much time in traveling over the State, and making examinations and collections in geology, as would be consistent with his other duties. In pursuance of this ordinance, Prof. Eugene A. Smith, then professor of geology in the university, at his own expense, passed a part of his vacation in 1871 in the examination of certain Tertiary deposits in Clarke, Washington, and Choctaw counties. The subject of a State geological survey was brought before the legislature of 1872–73, and the following act passed:

An act to revive and complete the geological and agricultural survey of the State of Alabama.

Whereas by an act of the general assembly approved January 4, 1848, and an act approved February 3, 1854, a geological and agricultural survey was instituted and prosecuted for some years, with great advantage to the people of the State; and

Whereas the said survey was left incomplete by the death of Prof. Michael Tuomey, State geologist; and

Whereas Dr. Eugene A. Smith, professor of mineralogy and geology in the University of Alabama, is required by ordinance of the board of regents of said university to devote a portion of his time and labor to a geological exploration of the State, and to an examination of its mineral and agricultural resources; therefore—

SECTION 1. *Be it enacted by the General Assembly of Alabama,* That Eugene A. Smith, professor of mineralogy and geology in the University of Alabama, be and he is hereby appointed State geologist.

SEC. 2. *Be it further enacted,* That the said State geologist shall make to the governor an annual report of the progress of his surveys and explorations of the mineral, agricultural, and other natural resources of the State, and upon the completion of the survey he shall make a full report of his labors, including surveys and explorations of mineral deposits, their location, and the best and most economical methods of development; of the qualities of soils, and their adaptation to agricultural purposes, together with analyses of soils, ores, minerals and mineral water, with maps, charts and drawings; which said report shall be printed, and shall be the exclusive property of the State.

SEC. 3. *Be it further enacted,* That it shall be the duty of the said State geologist to make collections of specimens, illustrative of the geological, agricultural, and mineral features of the State, one suite of which shall be deposited in the cabinet of the University of Alabama, a second suite in the cabinet of the Agricultural and Mechanical College, and a third in the office of the commissioner of industrial resources, in the State capitol at Montgomery.

SEC. 4. *Be it further enacted,* That for the outfit of the said survey there shall be appropriated out of any moneys in the treasury not otherwise appropriated—first, the sum of eight hundred dollars ($800) for the purchase of chemicals and the necessary apparatus of a laboratory for the analyses of soils, ores, minerals, and mineral waters; second, the sum of two thousand two hundred dollars ($2,200) for the purchase of an ambulance and team, and other equipments; third, an annual sum of five hundred dollars ($500) to pay the traveling and incidental expenses of the said State geologist during such time as he is engaged in the field work of the survey. The auditor shall, on the requisition of the said State geologist, when approved by the governor, draw his warrant on the treasury for the said sums as they shall be needed for the purpose of said survey as herein set forth; and the vouchers of said State geologist, for all expenditures made from this fund, shall be filed with the auditor, to be laid before the general assembly.

Approved April 18, 1873.

In 1877 a supplemental bill was passed making biennial appropriations of $200 for the purpose of preparing maps and other illustrations, and in 1879 still another, of which the following is a transcript:

An act to provide for printing and distributing the report of the State geologist, and for color plates, and printing the maps of the counties of Fayette, Marion, Walker, and Winston, which accompany said report.

SECTION 1. *Be it enacted by the General Assembly of Alabama,* That the State printer be, and he is hereby, required to print 1,000 copies of the report of the State geologist, made to the general assembly at the present session, one-half of which shall be sent to the State geologist for distribution.

SEC. 2. *Be it further enacted,* That it shall be the duty of the secretary of state to procure, from the lowest responsible bidder, color plates, and have printed 1,000 copies each of the maps of the counties of Fayette, Marion, Walker, and Winston, which accompany said State geologist's reports, which maps shall be turned over to the State printer and bound with said report.

SEC. 3. *Be it further enacted*, That in order to pay the expense of providing color plates and printing said maps the auditor be, and he is hereby, authorized and required to draw his warrant on the treasurer in favor of the State printer for the amount of the actual expense of such color plates and printing, in no event to exceed the sum of $250.

Approved February 12, 1879.

Personnel.—During the 10 years from 1873 to 1882, inclusive, Dr. E. A. Smith devoted the greater part of the three months of each summer vacation to geological excursions, receiving, however, no compensation in the way of salary, the cost of traveling and subsistence being paid, together with other contingent expenses, out of the appropriation of $500. During the summers of 1878 to 1882, Henry McCalley, assistant in the chemical department of the university, served as a volunteer assistant in the field, his actual expenses only being paid. Prof. W. C. Stubbs also voluntarily assisted in making chemical analyses, and T. H. Aldrich in preparing a sketch of the early coal-mining industry in the State. This was published in the report for 1875.

Publications.—During this period of 10 years there were published four annual reports, namely, for 1873, 1874, 1875, and 1876, and three biennial reports, namely, for 1877–78, 1879–80, and 1881–82.

With the exception of that upon agriculture (1881–82) these were of the nature of preliminary or reconnoissance reports, and dealt chiefly with the economic features of the State. The report for 1873 was simply a statement of the plan of the work proposed. That of 1874 was concerned with the crystalline region, and particularly with the copper-bearing strata. At the time when the examinations were made there, the whole section was greatly interested in the subject of copper, just as it has since become in gold. The next report (1875) treated of the same subject, but the greater part of it was devoted to the examination and classification of the formations of Jones Valley and the great Coosa Valley region. Professor Tuomey had recognized the occurrence in these valleys of the Silurian, Devonian, and Subcarboniferous formations, without undertaking the subdivision of the same, except in the case of the Clinton and Trenton. During the summer of 1875 Doctor Smith established the practical identity of these formations with what had already been so clearly described in Tennessee by Professor Safford, and also the fact of the existence in Alabama of the Ocoee, Chilhowee, Knox Sandstone, Shale, and Dolomite, the Lower and Upper Subcarboniferous with their respective minor divisions. The report for 1875 contained also Mr. Aldrich's sketch of the early history of coal mining in Alabama, to which reference has been made above; and there were also presented the records of the borings by diamond drill in the different parts of the Warrior Field together with an attempt at correlating the same. The report contained also many details of the occurrence and composition of iron ores and limestones of this district. The report for 1876 continued the examination of the valley regions, and contained a paper on the Alabama fresh water shells by Dr. James Lewis, contributed by Mr. Aldrich.

In 1877–78 attention was turned to the Warrior coal field. till then comparatively unknown, and maps were published of Walker. Fayette, Marion, and Winston counties, which were practically underlaid with coal measures. Notwithstanding the fact that no coal was mined at that time in all this region, and it was not possible with the means at the disposal of the survey to open the seams so as to show their true value, the publication, especially of the maps, turned the attention of investors to these counties, and the next few years witnessed great developments.

In 1878–79 a movement was set on foot to secure an appropriation from Congress for the purpose of making navigable the Upper Warrior River to develop the coal seams along its course, and Doctor Smith, with Henry McCalley and Joseph Squire, ran a line of levels from the forks of the Warrior down to Tuscaloosa, and made special reexamination of the coal seams within available distances from the river. The expense of this survey was borne chiefly by the War Department, but the map and report were published by the survey. In this document the details of the coal seams were given with a much greater degree of fullness than heretofore, together with many facts bearing upon their stratigraphical relations. There was also given by Mr. McCalley a continuation of the description of the Tennessee Valley, begun the year before, together with the analyses of some 50 coals from the Warrior field.

Expenses.—The cost of printing the reports of the survey was paid out of the general printing fund of the State. This amounted to $6,750, which, added to the $8,000 appropriated, gives a total of $14,750 for the 10 years' work, or an average of $1,475 a year.

As will be noted, the survey had no official connection with any other organization, though in 1880 Doctor Smith prepared for the Tenth Census a report on cotton culture in Alabama and Florida. the results of which, so far as Alabama was concerned, were published in the survey report for 1881–82. In addition to the special descriptive matter, this report contained a general discussion of the composition, mode of formation, and properties of the soil, and the changes produced by cultivation. The maps were prepared for the census work, but the survey was given the privilege of using the plates. The other illustrations were prepared by the survey.

Benefits.—The results accomplished by the survey during this period, as given by Doctor Smith, are as follows:

1. Every county in the State was visited, and the main features of the geology and resources of each were ascertained; descriptions were published of each of these counties, in some cases giving much detail; the main subdivisions of the geological formations in the State were established; the mode of occurrence and general distribution of the most important mineral resources were described and illustrated by many analyses; and the agricultural features of the entire State were given with an approach to completeness, thanks to the cooperation of the Tenth Census.

2. The experience and the knowledge of the territory acquired by the State geologist during this long period have unquestionably since been of benefit to the State, for without such experience on his part the disbursing of large sums and the directing of the work of the enlarged survey, so as to secure the best results and to avoid injudicious expenditures, would have been attended with many perhaps insurmountable difficulties. It might be added further that the cost to the State of this preliminary work, as shown above, was small.

3. On the other hand, while at the beginning of the work these preliminary reports supplied in a measure the information then demanded, it can not be denied that the progress of the State in the development of its great resources, especially in the latter part of this period, created a demand for much more detailed and special information in certain directions than the survey could supply without some greater expenditure of money.

THIRD SURVEY UNDER EUGENE A. SMITH, 1882–1900.

In accordance with the idea expressed in the last paragraph above, the following bill was introduced and passed by the general assembly during the winter of 1882–83:

An act to amend an act to revive and complete the geological and agricultural survey of the State of Alabama.

SECTION 1. *Be it enacted by the General Assembly of Alabama*, That the act entitled "An act to revive and complete the Geological and Agricultural Survey of the State of Alabama," approved April 18, 1873, be amended so as to read as follows:

SECTION 1. *Be it enacted by the General Assembly of Alabama*, That Eugene A. Smith, professor of chemistry and geology in the University of Alabama, be, and he is hereby, appointed State geologist.

SEC. 2. *Be it further enacted*, That the said State geologist shall make to the governor a biennial report of the progress of his surveys and explorations of the mineral, agricultural, and other natural resources of the State; and upon the completion of the survey he shall make a full report of his labors, including surveys and explorations of mineral deposits, their location, and the best and most economical methods of development; of the qualities of the soils, and their adaptation to agricultural purposes, together with analyses of soil, ores, marls, minerals, and mineral waters, with maps, charts, and drawings, which said report shall be printed and shall be the exclusive property of the State.

SEC. 3. *Be it further enacted*, That it shall be the duty of the said State geologist to make collections of specimens illustrative of the geological, agricultural, and mineral features of the State; one suite of which shall be deposited in the cabinet of the University of Alabama, a second suite in the cabinet of the State Agricultural and Mechanical College at Auburn, and a third suite in the office of the commissioner of agriculture at Montgomery, should such an officer be hereafter appointed and in case such an officer is not appointed then in the office of the secretary of state.

SEC. 4. *Be it further enacted*, That for the purpose of prosecuting expeditiously and thoroughly the work of the geological survey, the said State geologist shall have power to appoint, with the approval of the governor, such local and other assistants, including a competent chemist, and for such periods and with such compensation as he may deem necessary to the best interest of the survey. And to carry out the provisions of this act there shall be appropriated, out of any moneys in the treasury not otherwise appropriated, the sum of $5,000 per annum for the next 10 years. Upon the requisition of the said State geologist, when approved by the governor, the auditor shall draw his warrant on the treasurer for the amount appropriated in such sums as may be needed from time to time for the purposes of said survey as herein set forth; and for all expenditures made under the provisions of this act, except for the payment of the salary of the State geologist, as herein specifically set forth, the consent or approval of the governor shall be obtained, and the vouchers of the said State geologist for all expenditures made from this fund shall be filed with the auditor; and a statement of his receipts and expenditures shall be printed in each biennial report of the State geologist. Of the amount annually appropriated there shall be expended—

First. For the salary of the State geologist, $200 per month during such time as he may devote to the work of the survey, not to exceed the sum of $1,000 per annum.

Second. For the contingent expenses of the survey, including compensation of all temporary and permanent assistants; traveling expenses of the geological corps; purchase of materials for making the chemical analyses; other necessary expenditures for outfit; expenses incurred in providing for the transportation, arrangement, and proper exhibition of the geological and other collections made under the provisions of this act, and the engraving of maps, and sections to illustrate the biennial reports, $4,000: *Provided*, That nothing herein contained shall be construed as abridging the right of any subsequent general assembly to discontinue, diminish, or enlarge the amount of the appropriations herein made.

SEC. 5. *Be it further enacted*, That in the event of a vacancy in the office of the State geologist, by reason of death, resignation, or other cause, the governor is hereby authorized and required to fill such vacancy by appointment, and to fix the compensation of said appointee, to be paid out of the unexpended balance of the appropriation; and the tenure of office of said appointee shall continue till the next subsequent meeting of the general assembly.

SEC. 6. *Be it further enacted*, That all laws and parts of laws in conflict with the provisions of this act be, and the same are hereby, repealed.

Approved February 19, 1883.

In 1891, or before the expiration of the 10-year limit mentioned in Section 4 above, the amount of the annual appropriation was increased to $7,500, this amount to continue until otherwise ordered by the general assembly, the purport of the bill being to avoid the necessity of renewed legislation at every session. Under these laws assistants were appointed and assignments made as follows:

Personnel.—Henry McCalley to work in the Warrior coal field and the valley regions; Joseph Squire, in the Cahaba coal field; A. M. Gibson, in Murphree's Valley and the coal measures adjacent thereto, and afterward in the Coosa coal field. Doctor Smith, with D. W. Langdon, T. H. Aldrich, and L. C. Johnson, undertook the examination of the Cretaceous and Tertiary formations of the Coastal Plain, although a large part of the time of the director was occupied in administrative and editorial work. Later Dr. George Little made an examination of the clays of the Lower Cretaceous; Dr. W. B. Phillips began an investigation of the gold region, which was continued by W. M. Brewer; and K. M. Cunningham demonstrated the existence of true chalk deposits in the Alabama Cretaceous.

Methods and results.—The results accomplished up to 1900, given in Doctor Smith's summary, are as follows:

McCalley's report on the Warrior coal field, published in 1886, contained detail sections of all the exposures of coal seams in the basin division of this field, together with Mr. Gibson's account of part of the plateau division. This report also contained the first approximately full columnar section of the measures of this field. McCalley's report on the plateau region of the Warrior field, with map and colored section, appeared in 1891.

Squire's report and map of the Cahaba coal field appeared in 1890. The document purports to be the outcome of some 30 years' work, during which time Mr. Squire had been continuously engaged in this field, either in active mining or in making instrumental surveys for individuals or corporations, all the results of which were incorporated in his report. The map, it is claimed, showed accurately the surface outcrops of all the important seams of coal and a number of carefully constructed vertical and horizontal sections of the field. It exhibited also the geology of the adjacent valleys.

The existence of phosphatic nodules and marls in the State was discovered in 1884. The distribution, quality, and quantity of these were investigated by Mr. Langdon and the director, the report of progress being incorporated in Bulletin No. 2, 1892. Mr. Gibson's report on the geology and resources of Murphree's Valley did not appear until 1893. His report on the coal measures of Blount Mountain was issued in 1894, and his preliminary report on the Coosa coal field in 1895.

The preliminary report of Dr. William B. Phillips, who undertook the examination of the gold region, was issued in 1892 as Bulletin No. 3 and was concerned with the lower part of the gold belt. The upper part was undertaken by Mr. William M. Brewer, and his report thereon was published as Bulletin No. 5 in 1896. This report includes also notes on the microscopical characters of the crystalline rocks of this section by Dr. J. Morgan Clements and Alfred H. Brooks.

The State survey entered upon a plan of cooperation with the United States Geological Survey shortly after the consolidation of the various United States surveys into one organization under the direction of Clarence King. The results of this cooperation were manifested in Bulletin No. 4 of the State survey, published in 1892, and entitled A Report on the Geology of Northeastern Alabama and Adjacent Parts of Georgia, by C. W. Hayes; and Bulletin No. 43 of the United States Survey, published in 1887. This last-named bulletin treats of the Cretaceous and Tertiary formations of Alabama along the Tuscaloosa, Tombigbee, and Alabama Rivers, under the joint authorship of Director Smith and L. C. Johnson. The investigation of the Alabama Coastal Plain was continued by the Alabama survey and extended so as to embrace all the territory out to the Chattahoochee River, and the results were published in 1894 by the Alabama survey under the title, The Geology of the Coastal Plain of Alabama. In this investigation Dr. Daniel W. Langdon was associated with Director Smith, having immediate charge of the territory east of the Alabama River. It was while engaged in this work that Mr. Langdon made the discovery of the series of Post-Vicksburg Marine Tertiary formations, to which he gave the name "Chattahoochee." The credit of this discovery has been greatly diminished by the introduction of a number of new formation names and the restriction of the name Chattahoochee to the lowermost only of the formations which Mr. Langdon first brought to the attention of the geologists.

In the same year (1894) was published a geological map of the State on the scale of 1 inch to 10 miles. This map was accompanied by an explanatory chart of the same size as the map, on which were given, in columns, details concerning the several formations, as follows: 1, Names, Synonyms, Classifications, and Common Fossils; 2, Thickness, Lithological and Topographical Characters, Area and Distribution; 3, Useful Products; 4, Soils, Characteristic Timber Growth, and Agricultural Features; 5, Geological Reports containing most important details.

About this time Dr. William B. Phillips undertook the study of the conditions surrounding the manufacture of iron in the State.

and the first edition of his report on iron making in Alabama was issued in 1896. This book was so much in demand that an enlarged edition was brought out in 1898, and a third was in manuscript a year or two later, though not yet published.[1]

For many years Henry McCalley, chief assistant, devoted his whole time to the investigation of the Paleozoic formations of the State, and the results of his work were published under two heads, (1) The Geology and Resources of the Appalachian Valleys, and (2) A second report on the Warrior Basin.

The first of the two reports above indicated appeared in two parts, namely, the Valley Regions of Alabama, part 1, Tennessee Valley, issued in 1896; part 2, Coosa Valley Regions, issued in 1898, and including folding plate with numerous cross sections illustrating the geological structure.

The report on the Warrior Basin appeared in 1900. This report is illustrated by a large folding map, and by many vertical sections of the measures embracing the coal groups from the Brookwood down to and including the Black Creek. These reports include a mass of detailed information and will be an enduring monument to the untiring industry of Mr. McCalley. His later years were devoted to the study of the crystalline area, but he did not live to bring this report to completion.

A Preliminary Report on the Clays of Alabama with Chemical Analyses and Physical Tests of the More Important Varieties, by Dr. Heinrich Ries, was published in 1900. This report contains also a chapter on the Geological Relations of the Alabama Clays, by Dr. E. A. Smith.

The work of the survey was not limited exclusively to geology but included general natural history as well. The published reports along this line are, however, as yet confined to botany. In 1879 the botanical collections made by Doctor Smith were submitted to Dr. Charles Mohr, of Mobile, for classification, with the request that he would take charge of the future investigation of the flora of Alabama in connection with the Geological Survey. In 1880 a list of the combined collections of Doctors Mohr and Smith was published under the title A Preliminary List of the Plants Growing Without Cultivation in Alabama. In this list were enumerated about 1,500 species and varieties of native flowering plants and ferns. From this time on until his death, in 1901, Doctor Mohr was engaged in the study of Alabama flora under the auspices of the State survey and of the National Department of Agriculture, and a report on the Plant Life of Alabama, was in manuscript by the year 1900, and was published jointly as a report of the Alabama Geological

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[1] This was finally issued in 1912.

Survey, and as volume 6, Contribution from United States National Herbarium, by the United States Department of Agriculture. The proposed companion volume to this flora which was to have been devoted to the Economic Relations of the Alabama Flora, because of the untimely death of Doctor Mohr, was never completed.

The activities of the Alabama geological survey in the examination of water powers, underground water resources, cement materials. etc., extending over many years, did not find expression in the published reports until after the year 1900.

Expenses.—The appropriations for the survey expenses under Doctor Smith's administration have been as follows:

1873–1883, $500 a year for 10 years	$5,000
1873, for equipment	3,000
1883–1891, $5,000 a year for 8 years	40,000
1891–1900, $7,500 a year for 9 years	67,500
	$115,500

Not including cost of publication and incidental expenses, which, up to 1900, amounted to about $28,000.

Present condition of the survey.—The annual appropriation of $7,500 for the general expenses of the survey continues. The printing and illustrations of the geological reports are paid for out of the general fund of the State on the order of the governor and upon the recommendation of a committee consisting of the governor, the secretary of state, and State geologist. This committee decides as to the number of copies, the style of printing and binding, and the illustrations of the geological reports as they are announced to be ready for publication by the State geologist. By the Code of 1907 the compensation of the State geologist also is paid out of the general fund of the State, and not out of the survey appropriation as heretofore.

ADDENDA, 1910.

Very recently a handsome building (Smith Hall) has been erected at the university for purposes of the geological museum, offices of the geological survey, and the departments of geology and biology of the university. The main exhibition hall, about 100 feet by 60 feet, with gallery 13 feet wide and with skylight about 30 feet by 70 feet, provides for the exhibition and storage of the geological and natural history collections of the survey.

The existing laws relating to the geological survey are given in Bulletin No. 465, United States Geological Survey.

JOHN CASPER BRANNER

STATE GEOLOGIST OF ARKANSAS, 1887-92.

ARKANSAS.[1]

FIRST GEOLOGICAL SURVEY[2] UNDER DAVID D. OWEN, 1856–1859.

Organization.—The subject of a State geological survey of Arkansas was, according to Professor Branner, first brought to public attention by Governor Elias N. Conway in his message to the legislature of 1856. Upon his recommendation the matter was taken into consideration and an act passed on January 4, 1857, of which the following is a transcript:

An act to provide for a geological survey of the State of Arkansas.

SECTION 1. *Be it enacted by the General Assembly of the State of Arkansas,* That the governor be authorized and empowered to appoint a State geologist, to continue in office until the close of the next general assembly.

SEC. 2. *Be it further enacted,* That it shall be the duty of the State geologist to make reconnoissance of the State, noting the mining and mineral lands, their geographical position, extent, character, and geographical distribution; to examine and collect specimens of the ores of lead, iron, and other metals, of the marbles, granite, limestones, slates, and all other rocks of economic value, as well as the saline and mineral waters of the State; and to make a report of the result of his investigations, suitably illustrated, to the next regular session of the legislature.

SEC. 3. *Be it further enacted,* That a suitable room in the statehouse shall be set apart by the secretary of state, for the use of the State geologist, and the necessary cases and other furniture be furnished, sufficient to deposit specimens of all his collections on minerals and fossils, illustrating the different geological formations of this State.

SEC. 4. *Be it further enacted,* That the State geologist shall receive a salary at the rate of $1,800 per annum, payable quarterly by the State treasurer, and he shall be authorized, under the direction of the governor, to employ the necessary assistance and provide the necessary outfit, and the expenditures of such assistance and outfit, as well as traveling expenses and transportation, shall likewise be paid to him by the State treasurer, from time to time, as such expenses are incurred, upon a certified account of such disbursement, to be filed by said geologist, which shall be done under oath, accompanied by a statement of his accounts, with the original vouchers as near as can be obtained, and an account of items, to be filed with the auditor of the State.

SEC. 5. *Be it further enacted,* That the sum of $4,800 per annum be appropriated, out of any money in the State treasury not otherwise appropriated, for the payment of the salary of the geologist and all other expenses incurred.

SEC. 6. *Be it further enacted,* This law shall take effect and be in force from and after its passage.

Approved, January 15, 1857.

Under the provisions of this act Dr. David Dale Owen, then State geologist of Kentucky, was appointed State geologist, entering upon his duties October 1, 1857.

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[1] See also Geological Survey of Arkansas, by J. C. Branner, Journal of Geology, vol. 2, 1894, p. 826.

[2] Compiled in part from manuscripts by Richard Owen.

The results of the work accomplished during this and the following year are given in Owen's First Report of a Geological Reconnaissance of the Northern Counties of Arkansas, an octavo volume of 256 pages, bearing the date of 1858.

In his message to the legislature of 1858–59 Governor Conway recommended a more generous support of the survey—a recommendation which, in spite of some vigorous opposition, found expression in the following act, approved February 21, 1859:

An act to provide for the further prosecution of the geological, mineralogical, and chemical survey of the State of Arkansas, in connection with an agricultural and botanical survey of said State.

SECTION 1. *Be it enacted by the General Assembly of the State of Arkansas*, That the State geologist shall, in the further prosecution of the geological survey of the State, connect therewith an agricultural and botanical survey of said State, according to the plan hereinafter provided for by this act.

SEC. 2. *Be it further enacted*, That so soon as the geological reconnoissance of the State, now commenced, shall be sufficiently advanced to enable the geologist to decide upon which tracts of land demand a thorough detailed survey, there shall be instituted a minute and detailed survey of said tracts, commencing with those which hold out the best prospect of valuable discoveries, and said geologist shall employ, for the prosecution of the same, such force as the appropriation hereinafter provided for shall justify.

SEC. 3. It shall further be the duty of said geologist and his assistants to make collections of all ores, coals, building materials, hydraulic and other limestones, marls, clays, salts, soils, fossils, and other materials of economical value and scientific interest, to form a State collection.

SEC. 4. It shall further be the duty of said geologist and his assistants to make full and complete examinations, assays, and chemical analyses of all ores, minerals, and other useful materials, in order to determine their economical value, their durability, and their chemical constitution; and to test the mineral and natural waters of the State, and make analyses of those deemed of sufficient interest, especially those thought to be possessed of medical properties, or supposed to contain deleterious principles.

SEC. 5. That it shall further be the duty of said geologist and his assistants to make a collection of the various soils of the State, especially those characteristic of the different geological formations of the State; and shall constitute a minute analyses of such soils, so as to exhibit the composition and properties of the various soils, and ascertain their applicability to particular crops and their comparative fertility.

SEC. 6. That it shall be the duty of said geologist and his assistants to give information to the citizens in the country through which they may pass in regard to the existence of minerals, especially to the owners of land on which valuable minerals may be found.

SEC. 7. *Be it further enacted*, That the botanical survey shall have special reference to growths peculiar to the various geological formations and the congeniality of these (particularly the useful plants) to the soils derived from the different geological formations.

SEC. 8. That it shall be the duty of the said State geologist to prepare a report on the progress of said survey, on or before October 10, 1860, to be addressed to the governor of the State, and accompany said report with sections.

maps (and) drawings, to illustrate the text; also with specimens, to be deposited in the State cabinet.

SEC. 9. *Be it further enacted*, That the State geologist, or such of his assistants as shall be authorized by said State geologist, shall have access to records, of all documents, notes, profiles, plats, maps, and field books of all surveys of roads, rivers, railroads, or any other public surveys, with full authority to make such copies or extracts of the same as shall be deemed necessary or useful for facilitating and expediting the geological survey of the State.

SEC. 10. *Be it further enacted*, That for the purpose of carrying into effect the provisions of this act the governor be, and he is hereby, authorized, from time to time, to appoint a State geologist, who shall receive a salary at the rate of $2,500 per annum, payable quarterly out of the State treasury, and a sufficient sum to pay the same is hereby appropriated out of any money in, or which shall be in the State treasury, not otherwise appropriated.

SEC. 11. *Be it further enacted*, That the State geologist shall be authorized, under the direction of the governor, to employ the necessary assistance and outfit, as well as traveling expenses and transportation, which shall be paid to him out of the geological appropriations, from time to time, as such expenses shall be incurred, as well as the expenses of the chemical department and other expenses which shall be deemed necessary to accomplish the objects of this act; and all such expenditures shall be stated in the accounts of the State geologist, which he shall file with the auditor under oath; and that $6,000 per annum for two years be appropriated, out of any money in the treasury not otherwise appropriated, for carrying on the geological survey of the State of Arkansas; and all other acts of appropriation for said purpose are hereby repealed.

SEC. 12. *Be it further enacted*, That this act shall take effect and be in force from and after its passage.

Approved February 21, 1859.

Personnel.—Under this act Dr. David Dale Owen was again appointed State geologist, but, dying before the convening of the Legislature, his Second Report of a Geological Reconnaissance was edited by his brother, Richard Owen, and J. P. Lesley. This report was printed in Philadelphia under date of 1860, and forms an octavo volume of 433 pages.[1]

Doctor Owen was assisted by E. T. Cox, afterwards State geologist of Indiana, Joseph Lesley, Drs. Robert Peter and Elderhorst, chemists, and Leo Lesquereux, paleobotanist. The appointments, according to the manuscript notes of Richard Owen, were all dictated by Dr. D. D. Owen.

Salaries.—According to the terms of the bill establishing the survey, Doctor Owen's salary was at the rate of $2,500 a year. Prof. Richard Owen, in the manuscript note referred to, writes that the salary of Mr. Cox and that of the other assistants was $1,200 a year;

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[1] Concerning this Prof. Richard Owen writes (MS.): "Mr. Cox says the first volume was so badly printed by the State printer that Governor Conway had a second edition printed (I think in Philadelphia) at his own expense. All arrangements had been made by my brother for printing and engraving the second volume. Professor Lesley had also undertaken to read the proof."

and that of the subassistants was at the rate of $40 per month. None of the officers received salaries from other institutions.

Results.—According to Professor Branner, Doctor Owen's efforts were devoted entirely to the work of reconnaissance, the first report treating the region north of the Arkansas River, and the second that south of the river. In the main his ideas of the geological structure of the State were correct, and his facts have been of great service in working out the details of the structure and the areal geology. Errors were made, but they were few and unimportant, especially when we take into consideration the limited time and small means at the disposal of the survey. It may be well (quoting Doctor Branner) to mention the more fundamental of these errors, because they have so long been current:

1. It was thought that the Arkansas coals belonged to the Lower Coal Measures. Coal does occur in the Lower Coal Measures north of the Boston Mountains, and the generalization was made from these beds. The coal of the Arkansas Valley is in an altogether different position—near the top of the Coal Measures.

2. It was thought that the novaculites, now known to be Silurian, were Carboniferous. No fossils had then been found in or near the novaculites.

3. The theory of northeast-southwest metalliferous veins across the State, although advanced only as "probable," led to much searching for silver and lead, much loss of time and money, and to much disappointment.

The Civil War broke out shortly after the publication of Owen's second report, and the survey was discontinued through the following act:

> An act to repeal the one hundred and sixty-eighth chapter of Gould's Digest.
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> SECTION 1. *Be it enacted by the General Assembly of the State of Arkansas,* That the law providing for the appointment of a gelogist of this State, and for a geological survey of this State, as provided for by chapter 168 in Gould's Digest, be, and the same is hereby repealed: and that this act take effect and be in force from and after its passage.
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> Approved, January 21, 1861.

The books and specimens collected during the period of these surveys were disposed of according to the following:

> An act for the benefit of St. John's College.
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> *Be it enacted by the General Assembly of the State of Arkansas,* That the geological and mineralogical specimens on deposit in the office of the secretary of state be turned over to St. John's College and placed in its cabinet, for the use of the faculty, students, and others, and that the miscellaneous books on deposit in the office of the secretary of state be turned over to the said college, to be placed in their library for the use of the faculty, students, and others:

Provided, That said college shall return the whole of said books and specimens hereby deposited with them when called for by the State officers.

Approved, January 21, 1861.

The material thus disposed of would appear from the notes of Richard Owen to have been largely duplicates. He writes:

> I believe duplicate specimens were forwarded to Little Rock for a State museum. * * * On arriving at New Harmony [Owen's headquarters] all [that is, the specimens] were placed in one room of the laboratory, designated as the Arkansas room. * * * Some of the duplicates went to the Indiana State University. No special zoological collections were made and no library was formed.

SECOND GEOLOGICAL SURVEY UNDER W. F. ROBERTS, 1871.

In 1866 a bill providing for a second geological survey was passed by the senate of the general assembly, but was rejected by the house. In his message to the assembly of 1868 Gov. Clayton Powell recommended the continuation of the survey, but the committee to whom the matter was referred, reported that, "owing to the unsettled condition of the country and the lack of funds to prosecute the above work," the bill should be indefinitely postponed. In the assembly of three years later the subject received more favorable consideration, and the following bill was passed:

An act entitled An act to authorize the Governor to appoint a State geologist to develop the mineral resources of the State of Arkansas, and for other purposes.

SECTION 1. *Be it enacted by the General Assembly of the State of Arkansas*, That the Governor be and he is hereby authorized to appoint a State geologist, who shall hold his office for the term of two years.

SEC. 2. Any person who shall have been appointed under the provisions of this act shall, on receiving his commission, proceed to make a geological examination of the State, and report to the Governor the result of his explorations and discoveries once in three months.

SEC. 3. The State geologist appointed under this act shall be authorized to employ one or more assistants, who shall be under his supervision, and he shall be entitled to receive a salary of $2,500 per annum, all traveling and other necessary expenses.

SEC. 4. There shall be set apart in the office of the secretary of state a proper place for a mineral cabinet, and it shall be the duty of the State geologist to select choice specimens of all minerals that he may discover and deposit the same, properly labeled, in the mineral cabinet.

SEC. 5. *Be it further enacted*, That the sum of $15,000 is hereby appropriated out of any money in the treasury not otherwise appropriated to carry this act into effect.

SEC. 6. This act shall take effect and be in force from and after its passage.

Approved March 28, 1871.

Personnel and results.—Under the act Gov. P. A. Hoadley appointed W. F. Roberts, sr., State geologist on June 5, 1871. The records in the office of the secretary of state do not show how long Mr. Roberts held office, but in his message to the assembly in 1873 the governor mentions the fact that Mr. Roberts returned to Pennsylvania the preceding July, and had not since been heard from. Dr. George Haddock, of Arkadelphia, had been appointed Roberts' assistant, and accompanied him through the westerly part of the State. With what results is not definitely known, since Roberts' report was never published, the manuscript, according to the author's statements, being deposited in a bank because the State was unable to print it. A series of articles, however, was subsequently published in the *Age of Steel* of St. Louis in 1887–88, and it is regarded by Professor Branner as probable that these represented his views of the geology of the State, though they are largely a repetition of results given by Owen. In 1873 Dr. George Haddock published a pamphlet of 66 pages, entitled: Reports of a Geological Reconnaissance of a Part of the State Arkansas Made During the Years 1871–72. This was likewise of little importance and added nothing to the work of Owen.

THIRD GEOLOGICAL SURVEY UNDER GEORGE HADDOCK AND OTHERS, 1873–1874.

In the general assembly of 1873 the matter of a renewal of the survey was taken up and a bill passed as follows:

An act entitled An act to authorize the governor to appoint a State geologist to develop the mineral resources of the State of Arkansas, and for other purposes.

SECTION 1. *Be it enacted by the General Assembly of the State of Arkansas*, That the governor be and he is hereby authorized to appoint a State geologist, who shall hold his office for the term of two years, except he be removed as hereinafter provided.

SEC. 2. Any person who shall have been appointed under the provisions of this act shall, on receiving his commission, proceed to make a geological examination of the State, and report to the governor the results of the explorations and discoveries once every 12 months.

SEC. 3. The State geologist appointed under this act shall be authorized to employ one or two hands, who shall be under his supervision; and he shall be entitled to receive a salary of $2,500 per annum, all traveling and other necessary expenses.

SEC. 4. There shall be set apart, in the office of the secretary of state, a proper place for a mineral cabinet, and it shall be the duty of the State geologist to select choice specimens of all minerals that he may discover and deposit the same, properly labeled, in the mineral cabinet.

SEC. 5. The governor shall be authorized and shall have full power to remove the said State geologist whenever in his opinion the interests of the State may require it, and in that event the salary of the State geologist shall cease from the date of his removal.

SEC. 6. The sum of $15,000 is hereby appropriated to carry this act into effect.

SEC. 7. This act shall take effect and be in force from and after its passage.

Approved April 25, 1873.

Under this act the following geologists were appointed: George Haddock, appointed May 15, 1873, and removed from office January

14, 1874. Mr. Haddock, who is said to have been a Scotchman, had been assistant geologist under Mr. Roberts the year before; he made no report except the one published under a former appropriation and mentioned above. William C. Hazeldine, appointed January 14, 1874, and removed June 29, 1874. Mr. Hazeldine was an Englishman by birth, and had been a member of the State legislature from Richmond, Little River County, in 1871. Later he was circuit judge of the second district of Arkansas, and lived at Augusta, Woodruff County. As State geologist he made no report, and, so far as can be ascertained, did no field work. Arnold Syberg was appointed June 29, 1874, and remained in office to the end of the term. Mr. Syberg was a native of Prussia; was at one time a captain in the Regular Army of the United States; afterwards State engineer of the State of Arkansas, and still later engineer in the Confederate Army. He made no report, and the only work done was to receive and examine specimens sent or brought in from various parts of the State.

The total amount appropriated for the 1873–74 survey ($15,000) was spent, and, in addition thereto, the legislature voted $2,386 in a deficiency bill.

The failure of the surveys for the years 1868 to 1875 to yield any geological results must be attributed to the general demoralization of the State government during the reconstruction period.

No further efforts were made to carry on a geological survey until the year 1881, when bills for such work were defeated in both branches of the general assembly.

In the assembly of 1883 the only legislation passed relating to geological work was a senate concurrent resolution "authorizing and directing the governor to make application to the Secretary of the Interior of the United States for a geological survey of the State of Arkansas."[1] Nothing seems to have come of this effort to obtain help from the National Government.

FOURTH GEOLOGICAL SURVEY UNDER JOHN C. BRANNER, 1887–1893.

The fourth geological survey of the State was undertaken under the suggestion of Gov. Simon P. Hughes, in his message to the general assembly in January, 1887. The following is the text of the act of authorization:

A bill providing for a geological survey of Arkansas.

Be it enacted by the General Assembly of the State of Arkansas:

SECTION 1. That the governor is hereby required to appoint, by and with the advice and consent of the senate, a State geologist, who shall be a person of known integrity and competency, having a practical and scientific knowledge of the sciences of geology and mineralogy, who shall hold his office for the term of two years from the time he enters upon the duties of his office: *Provided*, That he shall be at all times subject to removal by the governor for incompetency or gross neglect of duty. That said geologist shall, upon consultation with and approval of the governor, appoint one or more suitable assistants, not exceeding three in number, one of whom shall be a skillful, analytical and agricultural chemist; the said geologist and assistants to constitute a geological corps, whose duty it shall be to make a complete and thorough geological, agricultural, and mineralogical survey of each and every county in the State.

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[1] Journal of Geology, vol. 2, 1894, pp. 829–830.

SEC. 2. The said survey shall have for its objects: First, an examination of the geological structure of the State, including the dip, magnitude, order, and relative positions of the several strata, their richness in coal, clays, ores, mineral waters, building stone, and other useful material for economic purposes, and their accessibility for mining, or manufacture; second, an accurate chemical analysis and classification of the various soils of the State, with the view of discovering the best means of preserving and improving their fertility, and of pointing out the most beneficial and profitable modes of cultivation; also, a careful analysis of the different ores, rocks, peats, marls, clays, saline, and all mineral waters within the State; third, to ascertain by meteorological observations the local causes which produce variations of climate in the different sections of the State; also, to determine by strict barometrical observations the relative elevation and depression of the different parts of the State.

SEC. 3. It shall be the duty of said geologist, in the progress of the examination thereby directed, to collect such specimens of rocks, ores, soils, fossils, organic remains, and mineral compounds as will exemplify the geology, mineralogy, and agronomy of the State; and he shall deposit said specimens, accurately labeled and classified, in a room to be provided by the State land commissioner, who shall carefully preserve and keep the same under his supervision.

SEC. 4. It shall be the duty of said geologist on or before the first Monday in December of each year during the time occupied in said survey, to make a printed report to the governor of the results and progress of the survey, accompanied by such maps, profiles, and drawings as may be necessary to exemplify the same, which reports the governor shall lay before the general assembly.

SEC. 5. When the survey shall be fully completed the said geologist shall make to the governor a final report, including the results of the entire survey, accompanied by such drawings and topographical maps as may be necessary to illustrate the same, and by a single geological map, showing by colors and other appropriate means, the stratification of the rocks, the character of the soil, the localities of the beds of the mineral deposits, and the character and the extent of the different geological formations.

SEC. 6. That the salary of said geologist shall be $3,500 per annum, and the salaries of his assistants not more than $1,800 per annum each, which salaries shall be paid at the time and in the manner now prescribed by law for the payment of the other State officers.

SEC. 7. That for the purpose of carrying out the provisions of this act there is hereby appropriated out of any money now in the treasury of the State not otherwise appropriated, for chemicals and for contingent expenses of the survey, including the actual and necessary traveling expenses of the geological corps and hire of local assistants, $10,000, which sum so appropriated shall be expended under the direction of the governor upon the certificate of said geologist, and approved by the governor, which certificate and approval shall alone authorize the auditor of the State to draw his warrant upon the treasurer for the amount so certified and approved.

SEC. 8. No money shall be paid for the purposes of said survey until said geologist shall have entered upon the discharge of his duties as prescribed by this act.

SEC. 9. The survey shall be commenced as soon after the appointment of said geologist and his assistants as practicable, and shall be completed within two years from and after the time of its commencement. To facilitate said survey the geologist and his assistants shall have access to the field notes and maps of the public surveys in the office of the commissioner of State lands free of charge. When, at any time during the progress of such survey, said geologist shall discover any considerable deposits of mineral, metals, ores, clays, coals, or anything else of value, situated upon the land or lands of any citizen or citizens of this State, he shall forthwith notify the owner or owners of such discovery or discoveries; and should any such discovery or discoveries be upon any land or lands belonging to the State, he shall at once and without delay notify the governor thereof; and the governor, upon the receipt of such notice, shall forthwith cause all such lands to be withdrawn from sale or donation until otherwise provided by the general assembly.

SEC. 10. That all laws in conflict herewith are hereby repealed, and this act shall take effect and be in force from and after its passage.

Approved March 5, 1887.

Personnel.—Under this act, Dr. J. C. Branner, then professor of geology in the University of Indiana, was appointed State geologist, entering upon his duties June 24, 1887. Assistants in special lines of investigation were from time to time appointed as follows: T. B. Comstock, to report on mines of gold and silver; R. A. F. Penrose, on those of manganese; L. S. Griswold, on novaculite; T. C. Hopkins, on marbles; and J. F. Williams, on the igneous rocks. R. N. Brockett served as chemist. Mr. Comstock resigning at the end of the first season, that of 1887, Mr. Arthur Winslow was appointed in his place. Volunteer assistance along various lines was furnished by O. P. Hay, of Butler University, Indiana; C. H. Bollman, of the University of Indiana; F. V. Coville, of Cornell University; F. W. Simonds, of the Arkansas Industrial University; R. T. Hill, of the United States Geological Survey; J. H. Shinn, of Little Rock, Arkansas; and G. D. Harris, of Jamestown, New York. Charles E. Taft served as topographer.

At the meeting of the general assembly in 1889 there was violent opposition to the continuation of the survey, due chiefly to the exposition of certain fraudulent claims regarding gold mines in the western part of the State. This opposition, was, however, unsuccessful, and the following bill passed. As will be noted, it was so worded that it was unnecessary for the subsequent assemblies to do more than vote the necessary appropriations.

An act providing for a geological survey of Arkansas, approved March 5, 1887, and appropriating ten thousand dollars to defray the expenses of said survey.

Be it enacted by the General Assembly of the State of Arkansas:

SECTION 1. That section 1 of an act providing for a geological survey of Arkansas, approved March 5, 1887, be amended so as to read as follows, to wit:

That the governor is hereby required to appoint, by and with the advice and consent of the senate, a State geologist, who shall be a person of known integrity and competency, having a practical and scientific knowledge of the science of geology and mineralogy, who shall hold his office for the term of two years from the time he enters upon the duties of his office: *Provided*, That he shall be at all times subject to removal by the governor for incompetency or gross neglect of duty. That said geologist shall, upon consultation with and approval of the governor, appoint one or more suitable assistants, not exceeding four in number, one of whom shall be a skillful, analytical, and agricultural chemist; the said geologist and assistants to constitute a geological corps, whose duty it shall be to make a complete and thorough geological, agricultural, and mineralogical survey of each and every county in the State.

SEC. 2. That section 6 of said act be amended so as to read as follows, to wit: That the salary of said geologist shall be $3,500 per annum; the salaries of three of his assistants shall be $2,000 per annum; and the salary of one of his assistants not more than $1,800 per annum, which salaries shall be paid at the time and in the manner now prescribed by law for the payment of the other State officers.

SEC. 3. That for the purpose of carrying out the provisions of this act there is hereby appropriated out of any money now in the treasury of the State not otherwise appropriated, for chemical and contingent expenses of the survey, including the actual and necessary traveling expenses of the geological corps and hire of local assistants, $10,000, which sum so appropriated shall be expended, under the direction of the governor, upon the certificate of said geologist, and approved by the governor, which certificate and approval shall alone authorize the auditor of State to draw his warrant upon the treasurer for the amount so certified and approved.

SEC. 4. That all laws in conflict herewith are hereby repealed, and this act shall take effect and be in force from and after its passage.

Approved March 29, 1889.

Under this bill Doctor Branner was again appointed State geologist. The assembly of 1891 made the same appropriation as for each of the two previous years, but with the stipulation that the survey should be brought to a close by the end of March, 1903. This, so far as the field work was concerned, was practically accomplished and further appropriations asked only sufficient to complete the preparation of the reports. The sum of $4,000 was appropriated for this with the understanding that Doctor Branner should prepare the reports without expense to the State beyond the assistance he might need in office and clerical work, and that the printing, binding, and engraving of the reports should be paid for, as before, out of the general appropriations for the State.

The reports, as issued, are mainly in the form of monographs, and, in the case of that of Penrose on manganese, by no means limited to deposits within the State limits. Annual reports alone were provided for, and for this reason the volumes, instead of being numbered consecutively, are given in this form and divided into volumes, of which each one is as a rule given up to a single subject.

The following laws were passed from time to time relative to the distribution of these reports:

[Act of 1889.]

SEC. 3. That there shall be printed by the proper contractor, annually, 2,000 copies of the report of the State geologist to the governor: *Provided*, That, with the approval of the board of public contracts, a larger number of said reports, or of any special reports of said State geologist, which may be of special value to the people of this State, may be printed: *and, provided further*, That the governor, with the approval of the board, may cause to be published any reports of the State board of health, or other important reports of State officers or agents, not provided for in chapter 123 of Mansfield's Digest.

An act to regulate the printing and distribution of the reports of the geological survey.

Be it enacted by the General Assembly of the State of Arkansas:

SECTION 1. The edition of the reports of the geological survey hereafter published shall be 4,000 copies. The distribution of these reports shall be made by the secretary of state, as follows; 50 copies to the governor; 10 copies to each of the members of the senate; 10 copies to each of the members of the house of representatives; 10 copies to each of the following State officers: The secretary of state, the treasurer, the auditor, the superintendent of public instruction and the land commissioner; 300 copies to the State geologist, who shall distribute them to professional geologists in this country and abroad, and to persons rendering material aid to the geological survey; 200 copies to the State librarian for exchange with other States and Territories. Of this number he shall also send a copy to each of the colleges of this State, and one copy to the library of the State university of each State in the Union. He shall distribute one copy to each of the following scientific societies of the United States maintaining libraries: California Academy of Sciences, San Francisco, Cal.; Connecticut Academy of Arts and Sciences, New Haven, Conn.; Smithsonian Institution, Washington, D. C.; Indiana Academy of Sciences, Indianapolis, Ind.; Davenport Academy of Natural Sciences, Davenport, Iowa; Iowa Academy of Sciences, Iowa City, Iowa; Boston Society of Natural History, Boston, Mass.; Museum of Comparative Zoology, Cambridge, Mass.; Peabody Academy of Sciences, Salem, Mass.; Worcester Natural History Society, Worcester, Mass.; Minnesota Academy of Natural Sciences, Minneapolis, Minn.; Academy of Science, Washington University, St. Louis, Mo.; American Geological Society; American Geographical Society, New York, N. Y.; American Institute of Mining Engineers, New York, N. Y.; American Museum of Natural History, Central Park, New York, N. Y.; New York Academy of Sciences, New York, N. Y.; Vassar Brothers' Institute, Poughkeepsie, N. Y.; Elisha Mitchell Scientific Society, Chapel Hill, N. C.; Cincinnati Society of Natural History, 108 Broadway, Cincinnati, Ohio; Academy of Natural Sciences, Philadelphia, Pa.; American Philosophical Society, Philadelphia, Pa.; Franklin Institute, Philadelphia, Pa.; Lackawana Institute, Scranton, Pa.; Wyoming Historical and Geological Society, Wilkes-Barre, Pa.

The remaining volumes, with the exception of 10 copies, which shall be retained in the State library, shall be sold by the secretary of state and the receipts covered into the State treasury. The price of the separate volumes shall be fixed by the printing board in such a manner as to have them cover as nearly as possible the average cost of printing, engraving, paper, binding, and necessary clerical work. Each volume may be sold separately, but a map shall not be sold separately from the volume of the report which it is intended to accompany, or the volume separately from its map or maps.

Sec. 2. That all laws and parts of laws in conflict with this act are hereby repealed, and this act shall take effect and be in force from and after its passage.

Approved April 1, 1889.

An act to regulate the distribution of the geological reports of the State.

Whereas there remains in the State library a large number of the geological reports of 1888; and

Whereas a much greater number is now in the hands of the public printer and will soon be issued; and

Whereas the principal object in making a geological survey of the State, and having the same published at a heavy cost, was to make known to scientists and capitalists the vast mineral resources of the State and induce an early development of the same; and

Whereas many applications for the geological reports of State are made by the citizens of other States and countries desiring to invest labor and capital in developing the mineral resources of this State; Therefore,

Be it enacted by the General Assembly of the State of Arkansas:

Section 1. That the secretary of state is hereby authorized and directed to distribute the geological reports of 1888, 1889, and 1890, as follows:

Report of 1888: To each member of the general assembly of 1891, 2 copies; to each State officer, 2 copies; to the State geologist (J. C. Branner), 100 copies; to the secretary of state for distribution in scientific institutions, scientists and capitalists in this and other States seeking information as to our mineral resources, 250 copies.

Report of 1889 and 1890: To each member of the general assembly of 1891, 5 copies; to each State officer, 5 copies; to the State geologist (J. C. Branner), 250 copies; to the States and Territories, 50 copies; to colleges and high schools of this State and universities and scientific institutions in other States and Territories, 100 copies; to the secretary of state for distribution to scientific institutions, scientists, and capitalists in this and other States seeking information as to our mineral resources, 350 copies.

Sec. 2. That the residue of said reports be retained in the State library for sale, at such price as the printing board may fix.

Sec. 3. That this act take effect and be in force from and after its passage.

Approved April 8, 1891.

An act to regulate the distribution of the geological reports of the State of Arkansas.

Be it enacted by the General Assembly of the State of Arkansas:

Section 1. That the secretary of state is hereby authorized and directed to distribute the geological reports of this State for the years 1888, 1889, 1890, 1892, and all subsequent reports as follows: To the State geologist (Prof. J. C. Branner), 150 copies each of all volumes hereafter published; to the States and Territories, one copy each of volume 1, 1891, and volume 2, 1892, and one copy each of all volumes hereafter published; to colleges and high schools of this State and universities and scientific institutions in other States, one copy each of all volumes published subsequent to volume 3, 1890; to the secretary of state, for distribution to scientists and capitalists, 150 volumes each of volumes 1, 2, 3, and 4 of 1888; 150 copies each of volume 2 of 1889; 150 copies each of volumes 1, 2, and 3 of 1890; 250 copies each of volume 1, 1891; 250 copies of volume 1, 1892; 250 copies each of all volumes hereafter published. To the members of the general assembly as follows: reports of 1888, one copy each; reports of

1889, one copy each; reports of 1890, volumes 1 and 2, one copy each; reports of 1890, volume 3, three copies each; reports of 1891, three copies each; reports of 1892, three copies each; of all volumes hereafter published, five copies each.

SEC. 2. That before the secretary of state shall be authorized to distribute any of the reports to scientists or capitalists as provided for in section 1, he shall require the applicant to state in writing "that he is a scientist or a capitalist," and that he wishes the reports to aid him in investigating the mineral resources of the State.

SEC. 3. That the secretary of state shall not be authorized to distribute any of the reports to scientists or capitalists until the postage or express charges on same have been paid.

SEC. 4. That the residue of said reports be retained in the State library for sale at such price as the printing board may fix.

SEC. 5. That all acts in conflict herewith be, and they are hereby, repealed, and that this act take effect and be in force from and after its passage.

Approved April 6, 1893.

Results.—The following are some of the general economic results of the survey's work as given by Professor Branner:

1. The areal and structural geology of the State in so far as the subdivisions are known. (The exact parting between the Carboniferous and Lower Carboniferous along the southern margin of the Carboniferous is not known; indeed it is not known whether the Lower Carboniferous comes to the surface south of the Arkansas River.)

2. Reporting upon the reputed gold mines of the State.

3. Outlining the coal area.

4. Determining and pointing out the adaptabilities of the various coals, and the best methods of mining and marketing them.

5. Showing the extent, value, and method of locating manganese deposits.

6. Mapping and calling attention to the character, extent, and distribution of the marbles and other limestones.

7. Discovery of chalk, giving its distribution, and suggesting uses to which it may be put.

8. Chemical analyses of the mineral waters.

9. Showing the character of the iron ores.

10. Discovery of bauxite and giving its distribution.

11. Pointing out the character, distribution, and availability of the clays of the State.

12. Determining by tests the character of the granites and giving their distribution.

13. Analyses and distribution of the zinc ores.

Some of the more comprehensive geologic problems that yet remain to be solved relate to—

1. The paleontology of the State.

2. The physical geography.

3. Quaternary history.

4. Relation of the paleozoic beds to those of the other parts of the continent and to those of the world.

5. The divisions of the Silurian beds.

Expenses of publications.—Summary of appropriations and publications.

Term.	Geologist.	Appropriation.	Reports published.	Volumes.	Pages.	Maps.
1857-1858	D. D. Owen	$4,800	First survey	1	256	
1858-1860	do	12,000	Second survey	1	431	1
1871-1873	W. F. Roberts, Sr.	[1] 15,000	Haddock's pamphlet	1	63	
1873-1874	Geo. Haddock W. C. Hazeldine A. Syberg	17,386	None			
	Total	$49,186		3	750	1

TOTALS OF BRANNER SURVEYS.

Term.	Geologist.	Appropriation.	Reports published.	Volumes.	Pages.	Maps.
1887-1889	J. C. Branner	$27,800	Reports for 1887-1888	5	1,105	5
1889-1891	do	32,600	Reports for 1889-1890	5	2,373	21
1891-1893	do	32,600	Reports for 1891-1892	4	887	5
1893-1895	do	4,000	In preparation [2]	4	[3] 2,000	38
	Total	$97,000		18	6,365	69

[1] Doctor Branner writes that but $10,700 of this amount was expended, the remaining $4,300 being carried over to the next survey. For the latter $17,386 was appropriated, but $19,628 expended. The extra $2,242 was presumably paid from the sum carried over as above.

[2] As given in Professor Branner's history of the Arkansas Survey, in the second volume of the Journal of Geology for 1894.

[3] About that amount.

Engraving, printing, and binding are not included in the total for the period 1887–1895. These items and the cost of fuel, lights, stationery, and postage would probably bring the total expenditures of the Branner survey up to about $120,000, and the total cost of all the State geological surveys up to $171,428.

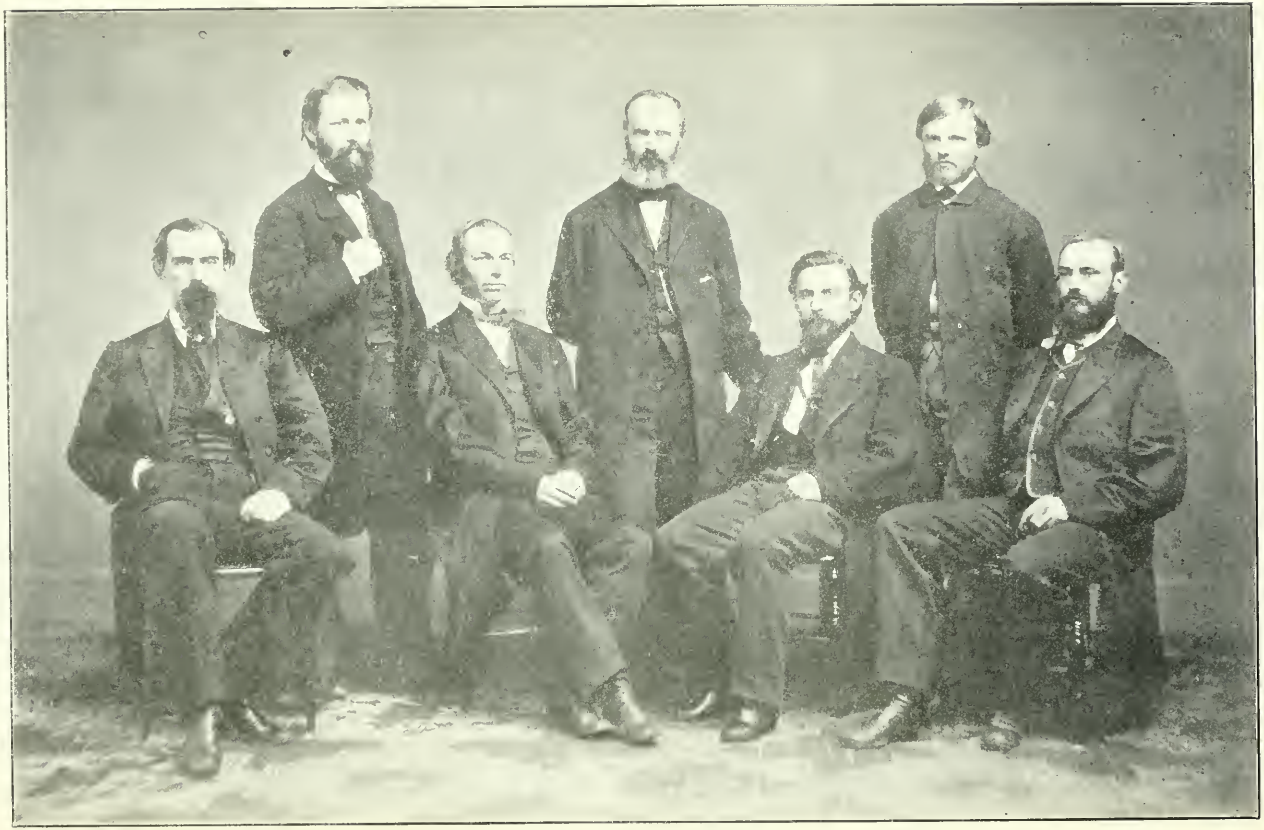
Concerning the volumes mentioned as in preparation, Professor Branner furnishes the following information:

1. The Zinc and Lead Regions of North Arkansas, by J. C. Branner. Pp. xiv+395 and atlas. Little Rock, 1900. (This was finally called a part of the report for 1892, because the active work was supposed to have ended in 1892.)

2. Report on the Coal Deposits of Arkansas, by Arthur Winslow, J. C. Branner, and others. This report was prepared, but no appropriation was ever made for publishing it. After much delay I finally asked the United States Geological Survey to publish it. The subsequent history appeared in Science, October 26, 1906, volume 24, pages 532–537, and December 7, 1906, volume 24, pages 722–728. * * * The results of subsequent work by members of the United States Geological Survey staff appeared as Bulletin 326. My own more detailed report with large scale maps remains unpublished.

3. Report on the Clays, Kaolins, and Bauxites, by J. C. Branner. The publication of this report was never provided for by the State. Part of it was published by the United States Geological Survey as Bulletin 351.

4. The Geology of the Lower or Barren Coal Measures of Arkansas, by J. C. Branner, J. H. Means, and G. H. Ashley. This report was likewise never provided for. Dr. Ashley's part on the region south of the novaculite area I had



Chester Averill, William More Gabb, William Ashburner, James Dwight Whitney, Charles F. Hoffman, Clarence King, William Henry Brewer

STATE GEOLOGIST OF CALIFORNIA AND ASSISTANTS, 1860-74.

published by the American Philosophical Society in its Proceedings, volume 36, pages 217–318. The parts by Means and myself were never published.

Other reports were also in preparation, one of which, on the Phosphate Rocks of Arkansas, by J. C. Branner and J. F. Newsom, the director of the Arkansas Experiment Station was induced to publish in 1902 as Bulletin 74.

There is also a lot of unpublished matter on the general geology and paleontology of the State and on the mineral resources.

CALIFORNIA.

FIRST GEOLOGICAL SURVEY UNDER DR. J. B. TRASK, 1850–1856.

Organization.—Leaving out of consideration the purely geographical explorations of Capt. J. C. Fremont in 1844, and Maj. W. H. Emory in 1846, and also the private work of Philip T. Tyson in 1850, the history of scientific surveys in California under public—that is State—auspices may be said to have begun with the appointment of Dr. John B. Trask as State geologist in 1853.[1] Doctor Trask, it would appear, had, of his own volition acquired a certain amount of information regarding the geology of the State, which, through a joint resolution of the legislature, was published as a State document in the form of a pamphlet of 31 pages entitled: A Report on the Geology of the Sierra Nevada, or the California Range.

On the 6th of May of this same year a joint resolution passed the assembly authorizing further geological examinations of some parts of the Sierra Nevada and Coast Mountains. The following is a transcript of this resolution:

> *Resolved*, That the senate and assembly of the State of California do hereby authorize Dr. John B. Trask to report more fully and especially on the unoccupied mineral lands lying upon the eastern borders of the valleys of the Sacramento and San Joaquin, and alluded to in his report of April 6, 1853, on the Geology of the Mineral District of Sierra Nevada, and contained in section 2 of said report, under head of "Mineral Resources"; said report to comprise, as near as possible, the area of such lands in each county in said valleys, and the facilities they offer, and requisitions necessary to insure their occupancy and improvement.
>
> *Resolved*, That an examination of the coast range, as far as practicable, and as far as the means within his power will admit of, be made, and that a full report be prepared and furnished the next legislature.
>
> *Resolved*, That the amount of money which the legislature may appropriate shall be a compensation for the information already obtained, and that which shall be embodied in the report to be made the next legislature.

The day following a supplemental act was passed, the purport of which was to reimburse Doctor Trask for previous outlay, and to enable him to continue the work. The wording of this act was as follows:

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[1] In 1852, at what was the third session of the legislature of the new State of California, a resolution was reported calling for immediate attention and action on the part of Congress, "not only for the purpose of more speedily developing the mineral resources of this State, but to enable the agriculturalist to predicate the success of his labors upon a sure data, and not be entirely dependent upon rains to sustain and mature his crops." Nothing seems, however, to have come of this.

An act to compensate Dr. John B. Trask for his report on the Geology of the Mineral Districts and to enable him to make further examinations.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The comptroller is hereby required to draw his warrant, in favor of Dr. John B. Trask, on the treasurer of State, for the sum of $2,000, to be paid for the geological report furnished by said Trask, and to enable him to prosecute further investigations relative to the same subject, under authority of certain resolutions passed by the senate and assembly.

Approved, May 7, 1853.

Under this act Doctor Trask again took the field and presented to the assembly of 1854 his second report, entitled: A Report on the Geology of the Coast Mountains and part of the Sierra Nevada, Embracing their Industrial Resources in Agriculture and Mining. This was printed in the form of a pamphlet of 95 pages. The results would appear to have been satisfactory to the legislature, for on May 15 of that year (1854) the following act was passed:

An act to authorize and enable Dr. John B. Trask to complete his geological examinations of parts of the State of California.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The sum of $5,000 is hereby appropriated, out of any moneys belonging to the general fund, to enable Dr. John B. Trask to complete his geological survey of the unexamined portions of the Coast Mountains, south of the thirty-fifth degree of north latitude, and certain parts of the Sierra Nevada, and report the same to the next legislature.

Publications.—The first report of Doctor Trask, a pamphlet of 31 pages, contains a sketch of the geology and mineral resources of the eastern valleys of the Sacramento and San Joaquin and to the coast line within the forty-first and forty-second degrees of north latitude. It is founded, as already noted, on personal observations made during the years 1850–1852. Doctor Trask's first report, in his capacity of State geologist, appeared in 1854 in the form of Senate Document No. 9, a pamphlet of 95 pages. This contained a description of the geology of the Monte Diablo range, Salinas Valley, from Point Pinos to the Nacimiento River, Santa Cruz Mountains; structure of the valleys of Sacramento and San Joaquin; review of the geological changes in the coast mountains and Monte Diablo range; classification of the rocks of the coast mountains and Monte Diablo range; position and relation of the volcanic rocks to the Tertiaries; volcanic rocks preceding the Tertiary era; most recent volcanic rocks of the coast mountains; changes of level and river terraces; soils of the valley Santa Clara and shores of the Bay of San Francisco; valley of the Salinas; soils of the Salinas; Pajaro Valley;

Livermore Valley; mineral resources of the coast mountains; mineral districts, embracing parts of the counties of Nevada, Placer, El Dorado, and Calaveras; quartz veins, and their relative age in California; character and position of the older veins below the surface; present government of metallic veins; descriptions of mines, with list of gold mines.

His second report appeared in 1855, forming Senate Document No. 14, a pamphlet of 94 pages, entitled: Report on the Geology of the Coast Mountains, Embracing their Agricultural Resources and Mineral Productions, also Portions of the Middle and Northern Mining Districts. It contained a description of the physical geography of the coast mountains; geology of the coast mountains; Tertiary rocks of the coast mountains; primitive rocks of the coast mountains; volcanic rocks of the coast mountains; geology of the San Bernardino Mountains; stratified rocks of the San Bernardino chain and plains of Los Angeles; extent of the infusorial group; plains of Los Angeles; artesian borings; soils and productions of Los Angeles; mineral productions of Los Angeles; country north of the American River; mineral district of the upper Sacramento Valley; geology of the northern coast mountains; Carboniferous limestone of the eastern part of Shasta County; Trinity County; structure of the Sacramento Valley; Tertiary rocks and other deposits of the Sierra Nevada; placer mining; quartz veins; quartz mines, with descriptions of mines, and statistics.

The third report, forming Assembly Document No. 14, of the session of 1856, comprised 66 pages. This contained a description of the physical geography of the region lying in the coast mountains north of the Bay of San Francisco; geological structure of the coast mountains; mineral character of the primitive rocks of the coast mountains; soils of Petaluma County; plains west of the Sacramento River; San Bernardino; geology of Table Mountain, Tuolumne County; Carboniferous rocks of the northern district; salines of the upper Sacramento Valley; Mammoth Mines, Seventy-six, Jamison Creek; descriptions of mines, etc.; analyses of saline waters from Lick Springs, Shasta County; gold mines in operation in 1855, and table of altitudes.

Expense.—The total expense of the Trask survey would appear to have been the $7,000 appropriated by the legislature of 1853–54.

SECOND GEOLOGICAL SURVEY UNDER JOSIAH D. WHITNEY, 1860–1873.

Following the work of Trask, the next official survey of California was undertaken by Prof. J. D. Whitney, in virtue of the following act:

An act to create the office of State geologist and define the duties thereof.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. J. D. Whitney is hereby appointed State geologist, whose duty it shall be, with the aid of such assistants as he may appoint, to make an accurate and complete geological survey of this State, and to furnish in his report of the same proper maps and diagrams thereof, with a full and scientific description of its rocks, fossils, soils, and minerals, and of its botanical and zoological productions, together with specimens of the same, which specimens shall be properly labeled and arranged, and deposited in such place as shall be hereafter provided for that purpose by the legislature.

SEC. 2. Said State geologist shall, as near as may be, at the beginning of each session of the legislature, present to the governor, who shall lay the same before the legislature, a report of progress, in which the operations of the geological survey during the preceding year shall be set forth and its more important practical results made public. He shall also furnish such estimates as he shall deem proper of the amount of the appropriation which shall be required for the continuation of the survey. His report shall also embrace the amount of expense incurred up to that period.

SEC. 3. On the completion of the survey the State geologist shall prepare and present to the governor a full and comprehensive report, embodying the results of the entire survey, with proper maps, diagrams, and drawings of the same; and the secretary of state is hereby directed to obtain the copyright for the same, as also of the annual reports of said geologist for the benefit of this State.

SEC. 4. Whenever one or more volumes of the geological survey herein provided for shall be published, the governor and secretary of state may cause such books to be sold upon the most advantageous terms to the State; and any moneys derived from such sales shall be placed to the common school fund of the State.

SEC. 5. The said geologist shall prepare for and superintend the publication of his reports of the final results of the survey provided for in this act, and he shall present to the legislature an estimate of the cost of such publication.

SEC. 6. The State geologist shall receive for his compensation the sum of $6,000 per annum, payable monthly, and his assistants shall receive such compensation as shall be determined upon by the governor and said geologist, which, together with the salary of the State geologist, shall be audited by the State controller, and paid out of the amount herein appropriated, or out of such appropriation as shall hereafter be made for that purpose: *Provided*, That the compensation herein allowed shall be paid only from the time they shall enter upon the performance of their duties.

SEC. 7. Whenever the said J. D. Whitney shall notify the governor of his acceptance of the appointment herein made, the governor shall cause to be issued to said Whitney his commission under the seal of State; and if the said Whitney shall decline to serve as said geologist, or die, or become unable to prosecute said survey, the governor of this State is hereby authorized to appoint some suitable person to prosecute said survey.

SEC. 8. The sum of $20,000 is hereby set apart out of any moneys in the State treasury not otherwise appropriated, as a special fund for the payment of the expenses incurred by said surveyor.

SEC. 9. This act shall take effect from and after its passage.

Approved April 21, 1860.

Under these apparently favorable auspices[1] a party, consisting of Prof. J. D. Whitney, W. H. Brewer, and William Ashburner, sailed from New York on October 22, 1860, arriving in San Francisco the 14th of November following. In order that field work might be carried on during the winter, the party repaired almost at once to the southern part of the State, where, during the time intervening from December 12 to February 7, a reconnoissance was made of a portion of Los Angeles and San Bernardino counties.

Brief reports were rendered from time to time, from which the following facts are largely gleaned. As announced in a notice of progress up to May, 1863,[2] the survey was governed by two principal ideas: First, to make as rapidly as possible a reconnoissance of the State with the view of acquiring a knowledge of its general geological structure, the age of the various formations which occur in it, and as complete a general idea as possible of their range and extent, so that a foundation might be laid for the detailed work which would follow the preliminary examination; second, at the same time that the general examination was going on, to work up in detail certain more important districts, so that the public might have light on questions of economical interest, and at the same time be able to form an idea of what the work might be, if ever carried to completion. Besides this, a natural history survey was to be carried on and material collected to form a State museum.

The survey authorized under the act of April 21, 1860, expired by constitutional limit on the same day of the same month of 1864. To enable the continuance of the work the following act was passed:

An act to create the office of State geologist and to define the duties thereof.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. J. D. Whitney is hereby appointed State geologist. He shall be commissioned by the governor, and it shall be his duty, with the aid of such assistants as he may appoint, to complete the geological survey of the State, and prepare a report of said survey for publication, and superintend the publication of the same. Such report shall be in the form of a geological, botanical, and zoological history of the State, and the number of volumes and the number of copies of each volume to be printed, and the style, form, maps, diagrams, or illustrations to be contained therein or to be published separately, shall be determined by the State geologist: and said report, when published, shall be sold upon such terms as the governor and secretary of state may decide upon, and the proceeds of such sales shall be paid into the common school fund of the State.

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[1] "No State geological survey was ever more auspiciously inaugurated, wisely provided for, or fraught with more interesting scientific and practical problems." *American Journal of Science*, vol. 30, 1860, p. 157. And again, on p. 424: "No similar enterprise in the United States has ever been set on foot on a more liberal and enlightened basis or opened under more favorable auspices as respects either the importance of the work to be done or the ability of those charged with the duty."

[2] Proc. California Acad. Sci., vol. 3, 1863.

SEC. 2. It is hereby made the duty of the State geologist and his assistants to devote the time not necessarily required in the preparation and superintendence for publication of the reports provided for in section 1 of this act, to a thorough and scientific examination of the gold, silver, and copper producing districts of this State, and to make such scientific and practical experiments as will be of value in the discovery of mines and the working and reduction of ores.

SEC. 3. The following sums of money are hereby appropriated, out of any money in the State treasury not otherwise appropriated, for the prosecution of the geological survey of the State, and for the sixteenth and seventeenth fiscal years: For salary of the State geologist, $9,000, to be drawn monthly on the last day of each month; for salary of two assistants, $6,600, to be drawn in the same manner as the salary of the State geologist; for publication of two volumes of report, $6,000; for office rent and expenses of survey in mining districts, and experiments in ores and all incidental expenses of work, $10,000, to be drawn one-half each fiscal year.

SEC. 4. This act shall take effect immediately.

R. BURNELL, *President of the Senate pro tem.*
WM. H. SEARS, *Speaker of the Assembly.*

Approved April 4, 1864.
FRED. F. LOW, *Governor.*

Notwithstanding the favorable conditions under which the Whitney survey was organized, it early became evident that there was a decided lack of sympathy between the legislature and the director of the survey. This is shown in the annual reports of Mr. Whitney and the numerous lectures which he delivered before the assembly. It is also evident from the fact that, as noted in his annual report dated 1869, while a committee of the assembly visited the survey and made a critical examination of the collections and publications, reporting unanimously in favor of the continuation of the work, nevertheless no definite action was taken by the legislature and a bill authorizing its continuation failed to pass the senate; still another, making appropriations to pay the outstanding debts of the survey and authorizing the executive to take possession of the property in the hands of the State geologist, met a similar fate.

Whitney was, nevertheless, unwilling to discontinue the work, even under these conditions, and, trusting in a more favorable action by future legislatures, continued it on a small scale. In this way a deficit, which at the close of 1867 had amounted to some $8,500, was increased to about $11,500 at the termination of the session of the legislature of 1867–68, at which time the field work was entirely suspended, leaving the work of publication still progressing, though the valuable collections were still unprovided for.

Up to December, 1867, there had been appropriated for the support of the survey the sum of $124,600. Two reports had been published and one large map, while five volumes of reports were in process of publication.

The adjournment of the legislature without taking any definite action in regard to the continuation of the survey left the whole of this work in the hands of the State geologist, who had entered into various contracts for printing, engraving, and for preparation of materials for the press. It therefore became a serious question with him whether the work should be stopped altogether, or he should endeavor to carry on the work at his own risk and expense and trust to another legislature to pass favorably upon the question of resuming the field work and completing the survey according to the original plan, the latter course being finally decided upon. That in so doing Whitney had not overestimated the possibilities of the case is shown by the following act passed by the legislature of 1869–70:

An act to settle and pay the unpaid expenses of the State geological survey.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. The board of examiners are authorized and directed to examine, and, if found correct, to allow all unpaid accounts of the State geologist for the expense of said survey up to April 30, 1868, and all expenses that have been incurred by or under the direction of the governor since that time for the preservation and protection of the property of said survey; but nothing herein contained shall authorize the payment of any salaries or expenses of said survey since April 30, 1868, except those authorized by (the) governor as aforesaid.

SEC. 2. All the proceeds from sales of the publications of said survey shall be applied, under the direction of the governor, to the completion of the unfinished publications of said survey.

SEC. 3. A sum not exceeding $25,000 is hereby appropriated, out of any money in the treasury not otherwise appropriated, to the payment of said accounts, when allowed by said board of examiners; but no money shall be paid under this act until all the property of every kind and description properly belonging to the State or to the survey, including instruments, specimens, preparations, and all other effects, shall have been first surrendered to the governor or such person as he shall authorize to receive the same.

SEC. 4. This act shall take effect immediately.

Approved March 16, 1870.

A few days later the following bill was passed to enable the continuation of the work for two years longer:

An act to continue the geological survey of the State of California.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. It shall be the duty of the State geologist to proceed, and with all reasonable diligence, complete geological survey of this State and the publication of the results thereof.

SEC. 2. The sum of $2,000 per month, payable monthly, for the period of two years, is hereby appropriated out of any money in the treasury not otherwise appropriated to pay the expenses of said survey and publication.

SEC. 3. This act shall take effect immediately.

Approved March 25, 1870.

Under the conditions of this act steps were taken toward the completion of the map of central California, which was intended to embrace the region from Owens Lake on the southern limit to Lassens Peak on the north, thus including about one-third of the area of the State. The sheet was not completed owing to the failure of appropriations.

In his report covering the operations for the years 1870–71 Whitney announced that of the 11 or 12 volumes contemplated in the regular series of volumes of the report, four had already been published, four more were under way, two only awaited the favorable action of the legislature to be at once put in hand, while two that had been begun had been suspended for want of means.

March 13, 1872, the following act was passed:

An act to continue the geological survey of the State of California.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. It shall be the duty of the State geologist to proceed and with all reasonable diligence complete the geological survey of this State and the publication of the results thereof.

SEC. 2. The sum of $2,000 per month, payable monthly for the period of two years from and after the 25th day of March, A. D. 1872, is hereby appropriated, out of any money in the treasury not otherwise appropriated, to pay the expenses of said survey and publication, and the controller is hereby directed to draw his warrants upon the treasurer and in favor of the State geologist therefor.

SEC. 3. This act shall take effect immediately.

Approved March 13, 1872.

Whitney, apparently becoming fully convinced by this time that no further moneys than those appropriated by the act of March 13 would be forthcoming, announced in his reports of the operations of the survey for 1872–73 that he had determined to close his office in connection with the State as soon as the maps and volumes had been completed, and that he would by no means retain the office of State geologist beyond the end of the fiscal year, June 30, 1875. He estimated that an amount of money not less than $100,000 would be required to complete the work already begun and in process of publication. This sum included the cost of completion of the map of central California and those in the vicinity of the Bay of San Francisco, and the most important mining districts, as well as the cost of publication of seven additional volumes on geology, ornithology, botany, and fossil plants, together with a folio atlas. This sum the legislature did not see fit to grant, and the survey passed out of existence simply through lack of funds.

Personnel.—The original party that sailed from New York comprised only Prof. J. D. Whitney, director, and W. H. Brewer and William Ashburner, assistant geologists. In 1861 C. H. Hoffmann became attached as topographer; Dr. J. G. Cooper, zoologist; and William Gabb as paleontologist. In 1862 the force was increased through the volunteer services of A. Remond and the employment of W. V. Wackenreuden as topographer. In 1863 it was still further increased by the volunteer services of Clarence King and James T. Gardiner.

In 1866 there were added F. E. Brown, H. N. Bolander, C. R. Brinley, A. Hartwig, A. W. Keddied, A. D. Wilson, and R. d'Heureuse. In 1870 Amos Bowman, W. A. Goodyear, and Alfred Craven were added to the force.

Beginning with 1862, F. B. Meek, of Washington, undertook the examination of the invertebrate fossils older than the Triassic and J. S. Newberry that of the fossil plants. The vertebrate fossils were referred to Joseph Leidy, of Philadelphia; the diatoms to A. M. Edwards; the mollusks to P. P. Carpenter; and the fishes to Theodore Gill.

Prof. S. F. Baird ultimately edited Doctor Cooper's ornithological notes, while F. H. Storer and S. F. Peckham, of Boston, received small allotments for chemical work on the hydrocarbons. Chester Averill acted as barometric observer throughout the existence of the survey.

Disposition of collections.—Section 1 of the act of 1860 provided for the collection of specimens which should be deposited "in such place as shall be hereafter provided for that purpose by the legislature." No such provision was, however, made during the life of the survey, although in 1863 it was—

> *Resolved, by the assembly, the senate concurring,* That Prof. J. D. Whitney, State geologist; John Swett, State superintendent of public instruction; and J. F. Houghton, surveyor general, be, and they are hereby, constituted a board of commissioners to report to the legislature, on or before the second Monday of December, 1863, upon the feasibility of establishing a State university, embracing an agricultural college, a school of mines, and a museum (including the geological collections of this State), and that said board report such facts and considerations as they may deem important in connection therewith.

In obedience to this resolution an elaborate report was submitted recommending the establishment of a State polytechnic school and the placing of the collections of the survey in a suitable fireproof building, in which should be ample accommodations for displaying and showing them, as well as room for a library, laboratory, and an office for the survey.

So far as can be learned from the annual reports no action was taken by the legislature on this recommendation, and it was not until 1874, on the discontinuance of the survey, that final steps were taken by the passage of an act, a transcript of which is given below:

An act to provide for the preservation of the material of the geological survey of California.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. It shall be the duty of the State geologist to deliver to the president of the University of California, Berkeley, in this State, all instruments, accoutrements, furniture, property, maps, books, drawings, manuscripts, notes, engravings, lithographic stones, wood cuts, field notes, and other material of every description and nature belonging or appertaining to the geological survey of California; such surrender and delivery to be made without delay.

SEC. 2. The regents of the University of California shall safely keep and preserve, at the said university, all the property and material referred to in section 1 of this act, until such time as the legislature may direct otherwise.

SEC. 3. The sum of $5,000 is hereby appropriated out of any money in the general fund not otherwise appropriated, to pay the necessary cost of arranging, packing, transporting, and delivering the said property and material; and the controller shall draw his warrant or warrants for such purpose, not to exceed said sum of $5,000, when directed to do so by the State board of examiners, and the treasurer shall pay the same.

SEC. 4. The regents of said university shall keep on hand and offer for sale all volumes of reports and maps published by said geological survey; they may also, as soon as the present supply of reports and maps is exhausted, cause any portion of the same to be republished and sold at the prices now provided or that may be hereafter provided by law; *Provided*, That said republication shall be done without cost to the State; *Provided further*, That the proceeds of the sale of all such maps and reports, over and above the cost of publication, shall be paid in to the State treasurer and by him credited to the school fund of the State.

SEC. 5. This act shall take effect immediately.

Approved March 27, 1874.

This act was preceded by the following:

Assembly Concurrent Resolution No. 60, requesting Professor Whitney to return to California all specimens collected by him. Adopted March 25, 1874.

Resolved by the assembly, the senate concurring, That Professor Whitney, late State geologist, be and he is hereby requested to return to the State of California all specimens collected by him during his official term as such State geologist, and that they be placed in possession of the faculty of the State University, for the use and benefit of State University.

Expenses.—The appropriations for the survey, as made by the various legislatures, were as follows. 1860, $20,000; 1860–61, $15,000; 1861–62, $15,000; 1862–63, $20,000; 1863–64, $24,600; 1865–66, $30,000; 1867–68, nothing; 1869–70, $73,000; 1871–72, $48,000; total, $245,600.

To which must be added the $13,000 mentioned by Whitney in his report for 1871 as having been received from the sale of publications, bringing the total cost for the 13 years up to $258,600, an average of $19,892.30 per year.

Publications.—At the time of the discontinuing of the survey—that is up to 1874—there had been published, in addition to the brief annual reports, two volumes on paleontology, one on geology, and one on ornithology. The remaining volumes constituting the reports of the survey were published under Whitney's direction, in Cambridge, Massachusetts, permission to this effect having been granted by the board of regents of the State University, in whose hands the matter had been left.

As originally planned by Whitney, the entire report was to comprise from 13 to 15 volumes, with an atlas and folio. The act of April 4, 1864, provided that these reports should be sold upon such terms as the governor and secretary of the state might decide, the proceeds of such sales to be paid into the common-school fund of the State. By the act of March 16, 1870, this ruling was changed, so that the proceeds of all such sales might be applied to the completion of unfinished publications. The amount thus rendered available up to November, 1871, as stated by Whitney in his report for that year, amounted to about $13,000. Subsequent acts relative to the distribution of publications were as follows:

An act to authorize the distribution of the reports of the State geological survey.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. On the application of any consul residing in the city of San Francisco and representing a European government, to the governor of the State of California, requesting a set of the reports of the State geological survey, to be deposited in some well known and established scientific or literary institution under the control of the government of which he is the accredited representative, an order may be issued from the governor to the secretary of state or the State geologist, as the case may be, directing them to furnish one such set of reports only to each nation having a consul residing in San Francisco; provided further, that the State superintendent of public instruction shall be furnished, on demand on the secretary of state and the State geologist, with one set for the State Normal School, two sets for the State University, and two sets for the State Library.

SEC. 2. The secretary of state or the State geologist on the presentation of such order, shall deliver to the party therein named such set or parts of set of the reports of the State geological survey as may be designated, taking his receipt therefor. They shall annually, on the first day of September of each year, report to the governor the number of volumes so issued, at whose request, and to what institution presented.

SEC. 3. This act shall take effect immediately.

Approved February 2, 1872.

An act supplementary to an act entitled An act to authorize the distribution of the reports of the State geological survey, approved February 2, 1872.

The people of the State of California, represented in senate and assembly, do enact as follows:

Section 1. Of each of the volumes and maps of the State geological survey already published, or which may be hereafter published, 100 copies shall be deposited at the office of the secretary of state by the State geologist, subject to the order of the governor, for gratuitous distribution to the various State and Territorial libraries, to public libraries, and to the libraries of universities, colleges, and learned societies in the United States.

Sec. 2. One hundred copies of the same may be distributed by the State geologist to public libraries and learned institutions in foreign countries, to the officers of other geological surveys, and to persons who may have rendered special services to the geological survey of California.

Sec. 3. On application by the county clerks of the respective counties to the State geologist, one copy of each of same shall be given to each county in the State of California, to be deposited and kept with the county records, and to be accessible at all reasonable hours for inspection by the general public, the county clerk being held responsible for the safe keeping of the same.

Sec. 4. The secretary of state and the State geologist shall each keep a record of the volumes and maps thus distributed, specifying the names of the institutions or individuals to whom the same are given, and the State geologist shall biennially communicate such record as kept by him to the office of the secretary of state, where a complete record of the distribution herein provided for shall be preserved.

Approved April 1, 1872.

Results.—As before noted, the reports of this survey are embodied in three volumes on geology and paleontology, published by the State, and two volumes on the auriferous gravels, published by the Museum of Comparative Zoology at Harvard after Whitney's retirement. It was announced by the statement of progress for 1872–73 that a geological map of the whole State had been colored, but it seems not to have been issued. The first volume, or Report of Progress and Synopsis of Field Work for 1860–1864, appeared in 1865. This was a quarto of 498 pages. It contained a great amount of descriptive matter relating to the areal geology of various parts of the State, particularly of the Coast Ranges and Sierra Nevada, with a chapter on the mining regions. It was announced on the discovery of a single shell in the rocks of Alcatraz Island that the socalled San Francisco was of undoubted Cretaceous age. The serpentines of Mount Diablo and the San Francisco Peninsula were considered to be metamorphic sediments—a mistake repeated by later observers. Whitney was decidedly pessimistic regarding the probability of the occurrence of petroleum on the Pacific coast, and unhesitatingly discouraged the promoting of enterprises of this nature. It was due to his stand regarding this particular project that arose, according to his own account, much of the antagonism to the survey from speculators and promoters, whose efforts at selling stock were thereby checked. "Petroleum is what killed us. By the word 'petroleum' understand the desire to sell worthless property for large sums and the impolicy of having anybody around to interefere with the little game," he wrote.

All those chains or ranges of mountains in California which had been uplifted since the deposition of the Cretaceous were considered to belong to the Coast Ranges: those which were elevated before the Cretaceous, to the Sierra Nevada. The slates of the western slope in Mariposa County were identified as of Jurassic age, and the calcareous slates of Plumas County as Triassic. The limestones in the Gray Mountains had been previously referred by Trask to the Carboniferous, and to this Whitney agreed. The peculiar dome-shaped concentric structure of the granite in the Sierras was dwelt upon with considerable detail, and the curved structure of the sheets thought to have been produced by the contraction of the material while cooling or solidifying. The Yosemite Valley itself Whitney thought to be due to a differential movement, the half dome seeming beyond a doubt to have been split asunder in the middle, and one-half to have gone down in what he called "the wreck of matter and the crush of worlds." In other words, he considered the valley as due to the downward drop of an enormous fault block.

The first volume of the palentological reports appeared in 1864. This comprised 243 pages, with 32 full-page plates of fossils. Concerning the work thus far done, Whitney wrote, in the American Journal of Science for November, 1864:

> Perhaps the most striking result of the survey is the proof we have obtained of the immense development of rocks, equivalent in age to the upper Trias of the Alps, and paleontologically closely allied to the limestones of Hallstadt and Aussee, and the St. Cassian beds, that extremely important and highly fossiliferous division of the Alpine Trias. * * * Enough fossils have been found to justify the assertion that the sedimentary portion of the great metalliferous belt of the Pacific coast of North America is chiefly made up of rocks of Jurassic and Triassic age. While we are fully justified in saying that a large portion of the auriferous rocks of California consist of metamorphic Triassic and Jurassic strata, we have not a particle of evidence to uphold the theory * * * that all or even a portion are older than the Carboniferous. * * * We are able to state * * * that this metal (gold) occurs in no inconsiderable quantity in metamorphic rocks belonging as high up in series as the Cretaceous.

The second volume of the paleontological reports, published in 1869, comprised 299 pages with 36 full-page plates, and was given up wholly to descriptions of Tertiary and Cretaceous fossils. In the introductory note the statement is reiterated concerning the age of the gold-bearing rocks, and the absence of rocks older than Carboniferous not merely in California but in the whole region west of the one hundred and sixteenth meridian.

The topographic work of this survey, under the direction of Hoffmann, has been claimed verbally by Prof. W. H. Brewer to have been considerably in advance of any heretofore undertaken. He introduced a system of rough triangulation well adapted to the needs of the survey, but his contours were indicated by hachures.

As to the exact cause of the failure of the survey under Whitney opinions may differ. It was a by no means unusual fate in the history of State surveys, and reasons of one kind and another are easy to find. Taken all in all that given by Dr. Rossiter W. Raymond[1] seems in the light of present knowledge to best fit the case:

> It happened that, when a question of a further appropriation was pending, the only report which had been issued by the survey (Whitney's) was a volume on paleontology; and an opponent of the appropriation carried the house with him by simply reading random extracts from that dry and technical treatise, as samples of the character of the work which had been done at the public expense up to that time. The appropriation was refused, and the valuable work of Bowman and others, on the old river channels of California and their gold-bearing gravels and cements, was thereby barred from publication for several years. For this result Prof. J. D. Whitney, the distinguished head of the survey, has often been blamed, on the ground that he expended money and time in a preliminary topographical and geological survey without attacking problems of immediate industrial interest. Personally I think there is some foundation for this criticism. Professor Whitney, with a lofty and serene regard for the logical sequence of science, and an equal disregard for the clamor of industrial interests, had begun his work with the topographical reconnoissance necessary as a basis for accurate geological deductions and correlations; and, in the course of this preliminary labor, his field parties had made incidentally many interesting paleontological observations, undoubtedly significant in their bearing upon the geology of the State. Professor Whitney had also started investigations of more immediate and evident practical importance, but unfortunately, in his plan of a permanent and monumental scientific achievement, these were not of prime importance and were advancing slowly. Probably the thought never occurred to him that it would make any difference what he published first as the fruit of his work for the State, and thus he made the profound mistake in policy of issuing, merely because it was ready, a learned book on palaeontology for the benefit of a limited outside public of specialists, and to the profound dissatisfaction of the people who had paid him and were, reasonably or unreasonably, expecting something else for their money.

ESTABLISHMENT OF A STATE MINING BUREAU, 1880–1900.

By an act of the legislature, approved April 16, 1880, there was created a State mining bureau and in conjunction therewith the office of State mineralogist. The wording of the act was as follows:

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[1] In a footnote to a Biographical Sketch of J. D. Hague, Bull. No. 26, Amer. Inst. Min. Engs., 1909, p. 113.

Assembly bill No. 415, approved April 16, 1880.—An act to provide for the establishment and maintenance of a mining bureau.

The people of the State of California, represented in senate and assembly, do enact as follows:

SECTION 1. There shall be and is hereby established in this State a mining bureau, the principal office of which shall be maintained in the city of San Francisco, at which place there shall be collected by the State mineralogist and preserved for study and reference, specimens of all the geological and mineralogical substances, including mineral waters, found in this State, especially those possessing economic or commercial value, which specimens shall be marked, arranged, classified, and described, and a record thereof preserved, showing the character thereof and the place from whence obtained. The State mineralogist shall also, as he has opportunity and means, collect, and in like manner preserve at said office, minerals, rocks, and fossils of other States, Territories, and countries, and the collections so made shall at all reasonable hours be open to public inspection, examination, and study.

SEC. 2. It shall be the duty of the governor to appoint a citizen of this State having a practical and scientific knowledge of mining and mineralogy to the office of State mineralogist, to hold his said office for the term of four years, or until the appointment and qualification of his successor, who shall take and subscribe the oath of office prescribed by the constitution, and who shall receive for his services a salary of $3,000 per annum, to be paid as other officers of the State are paid, and shall also receive his necessary traveling expenses when traveling on the business of his office, to be allowed and audited by the State board of examiners, the whole to be paid out of the mining bureau fund hereinafter provided for, and not otherwise.

SEC. 3. In addition to the collection, classification, arranging, and preservation of specimens, as provided in the first section of this act, it shall be the duty of the State mineralogist to make analytical assays as required; and, when the funds in the mining bureau fund are sufficient therefor, to provide and maintain a library of works on mineralogy, geology, and mining; to arrange in cases such specimens as he may collect; to procure and preserve models and drawings of mining machinery, and of milling machinery used in the reduction of ores; to correspond with established schools of mining and metallurgy, and obtain and preserve for public inspection and use such information respecting improvements in mining and mining machinery as will be of practical value to the people of this State; to visit the several mining districts of each county of the State from time to time, ascertain and record their history, describe their geological formation and altitudes, the character of the mines and ores, and the general development of the district. At the close of each year he shall make a report in detail to the governor, showing the amount of disbursements of the bureau under his charge, the number of specimens collected, and giving such statistical information in reference to mines and mining as shall be deemed important.

SEC. 4. The State mineralogist may, from time to time and as the funds in the mining bureau fund will permit, appoint such assistants as he may deem necessary and proper for the carrying out of the objects of this act, and the efficient provision and maintenance of a bureau of mining information and statistics, and may procure and maintain the necessary rooms and furniture for the office and uses of the bureau in San Francisco; but the entire expenses of the bureau for salaries, assistance, rents, furniture, fuel, and all other things pertaining to the bureau must not, in any one year, be greater than can be paid out of the mining bureau fund herein provided for.

SEC. 5. For the purpose of establishing a fund for the maintenance of said mining bureau it shall be the duty of the tax collectors in the several counties in this State, and of the license collector of the city and county of San Francisco, on the second Monday in January, April, July, and October, in each year, to transmit by express to the State treasurer all moneys collected by them from mining corporations, or from corporations formed for milling ores, or for supplying water for mining purposes, under or by virtue of the act entitled "An act imposing a tax on the issue of cetificates of stock corporations," approved April 1, 1878, and to forward to the State controller by mail a certificate showing the amount of money so forwarded to the State treasurer and the date when the same was transmitted, and also showing the names of the several corporations from which the same was received and the amount received from each. The State treasurer shall receive the amounts so transmitted and give duplicate receipts therefor, one of which shall be filed with the State controller and the other shall be returned by mail, or return express, to the collector from whom the money was received; and after paying out of the money so received the charges for the transmission thereof, the amount of which shall be noted on the receipt filed with the State controller, he shall retain the remainder in his hands as a separate fund, to be known as the mining bureau fund, to be used only in payment of drafts made for the expenses of the mining bureau established under this act, and out of which all the expenses of said bureau shall be paid.

SEC. 6. Such tax collectors and license collector shall hereafter be required to pay into the county treasuries of their respective counties only that portion of the moneys collected by them under the act of the legislature mentioned in the last preceding section which is collected from corporations other than those mentioned in section 5 of this act.

SEC. 7. This act shall take effect and be in force from and after its passage.

Under this act Mr. Henry G. Hanks was appointed State mineralogist and served until May 13, 1886, when he was succeeded by William Irelan, Jr. Soon after the institution of the bureau it had become evident to the State mineralogist that the fundamental act was radically defective. and in 1885 a supplemental act was passed, as follows:

An act supplementary to an act entitled "An act to provide for the establishment and maintenance of a mining bureau," approved April 16, 1880.

The People of the State of California, represented in Senate and Assembly, do enact as follows:

SECTION 1. All property of this State pertaining to said mining bureau and the money and financial affairs thereof shall be vested in and be under the direction and control of a board of trustees of said bureau.

SEC. 2. It shall be the duty of the governor of the State to appoint five citizens and residents of this State to be such trustees.

SEC. 3. The appointees herein mentioned, when assembled, shall constitute the board of trustees of the State mining bureau, three of whom shall constitute a quorum. The board shall have power, by said name, to sue and defend. They shall keep a record of all their proceedings, and they shall elect one of those so appointed to be president of the board, and shall have the right to appoint a custodian of the museum and other employees. The State mineralogist shall be the director of the museum, and shall have the right to appoint a custodian of the museum and other employees, subject to the approval of the board of trustees, and it shall be his duty to consult the board in all matters of importance.

SEC. 4. Said board shall make rules for its own government, for regulating the custody and disbursement of funds, and the mode of drawing the same from the State treasury.

SEC. 5. The board of trustees shall, annually, report to the governor of the State the condition of the bureau, with a statement of the receipts and expenditures in detail, which report shall be published in the annual report of the State mineralogist provided for in the act to which this is supplementary.

SEC. 6. The trustees are hereby empowered to pay out of any moneys coming into their hands the amount advanced by Wells, Fargo & Company, shown in the financial statement of the State mineralogist and published in his report.

SEC. 7. The board of trustees shall be empowered to receive, on behalf of the State, bequests or gifts, legacies and devises, real estate and other property, and to use the same in accordance with the wishes of the donors; and if no instructions are given, to use their discretion for the best interests of the State museum.

SEC. 8. The board of trustees may, with the assistance of the State mineralogist, prepare a special collection of ores and minerals of California, to be sent to any World's Fair or exposition at which they may deem it desirable to display the mineral wealth of the State.

SEC. 9. All acts or laws in conflict with this act are hereby repealed.

SEC. 10. This act shall take effect immediately.

Under this act William Irelan, jr., S. Heydenfeldt, jr., J. I. Davis, W. E. Dean, and George Hearst were appointed trustees.

The bureau, as organized under this law, had for its immediate motive the collection and preservation, for study and reference, of materials pertaining to economic geology, and to make assays and furnish information relative to the resources of the State and their utilization. It was to be sustained in part by a tax on the issue of certificates of stock corporations. In addition, appropriations for geological work were from time to time made by the State legislature. Under these conditions the bureau fund was a somewhat variable quantity, rarely amounting to more than $2,000 or $3,000 annually, while the legislative appropriations were some $10,000, $15,000 or $25,000, for the running expenses of the bureau and for field work.

Personnel.—The term of office of the State mineralogists was by the original act limited to four years, or until the appointment and qualification of his successor. The various incumbents and their periods of service were as follows: Henry G. Hanks, 1880 to May 10, 1886; William Irelan, Jr., from 1886 to September 15, 1892; J. J. Crawford, 1892 to 1896; and A. S. Cooper, 1896 to 1900, the latter being in turn superseded by L. E. Aubrey. The following list comprises the names of those who have from time to time served as field assistants, and who, according to the terms of the law (sec. 4), were appointed by the State mineralogist. The salaries of the assistants was left discretionary, that of the State mineralogist alone being fixed by law at $3,000 a year.

Assistants on California State mining bureau: C. H. Aaron, Melville Atwood, Myron Angell, C. C. Van Blarcom, A. Blanc, Stephen Bowers, J. A. Brown, R. E. Browne, J. H. Crossman, H. De Groot, W. H. Fairbanks, L. P. Goldstone, J. F. O. Gorman, W. A. Goodyear, J. B. Hobson. W. D. Johnson (Chemist), Samuel Locke, A. McGregor, J. A. Miner, W. P. Miller, F. C. Mathyas, J. H. Means, C. A. Ogden, E. B. Preston, L. C. von Pelersdorf, T. J. Quimby, L. Silver, W. H. Storm, J. H. Tibbett, F. F. Thomas, W. L. Watts, H. A. Whiting. F. H. Wheeler, E. A. Wiltsee, Charles G. Yale.

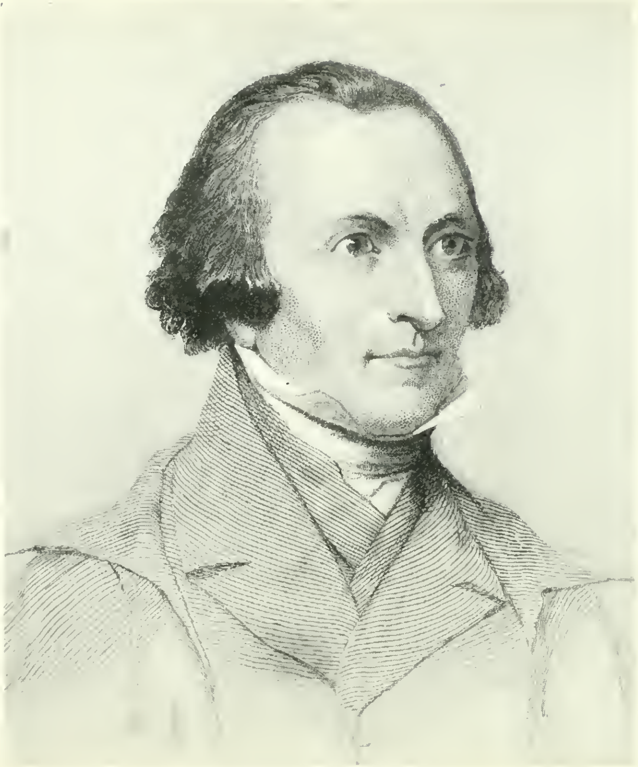
Expenses and appropriations.

October 1, 1880, to September 1, 1882	$20,858.65
September 1, 1882, to June 1, 1883	3,087.25
May 15, 1880, to May 15, 1884	41,941.17
May 15, 1884, to May 15, 1885	7,818.82
April 16, 1885, to July 13, 1886	25,664.44
July 13, 1886, to July 1, 1887	36,893.90
July 1, 1887, to July 1, 1888	35,044.60
October, 1889, to October, 1890	54,653.05
October 1, 1890, to July 1, 1891	5,228.80
July 1, 1891, to July 1, 1892	30,128.05
July 1, 1892, to July 1, 1893	28,102.00
July 1, 1893, to July 1, 1894	27,480.00
July 1, 1894, to July 1, 1895	27,361.80
July 1, 1895, to July 1, 1896	26,908.70
July 1, 1896, to July 1, 1897	25,000.00
July 1, 1897, to July 1, 1898	25,000.00
July 1, 1898, to July 1, 1899	25,000.00
July 1, 1899, to July 1, 1900	25,000.00
Total	$471,171.23

Publications.—Annual and biennial reports were issued, and, in addition, up to 1900, 20 bulletins, including the last issued under the Cooper administration and bearing the date 1901. The subject matter of all these is largely of an economic nature and much of necessity of only transient value. The tenth annual report, it should be noted, issued during the administration of William Irelan, Jr., contained a colored geological map of the State.

The bureau is still in active existence at the time this publication goes to press.

Museum and library.—An extensive museum and valuable library have been built up under the organization, the same being at present housed on the second floor of the Ferry Building, at the foot of Market Street. The library, in the report for 1907, was said to contain upwards of 4,000 to 5,000 volumes and many pamphlets.



JAMES GATES PERCIVAL

CHARLES UPHAM SHEPARD

STATE GEOLOGIST AND MINERALOGIST OF CONNECTICUT, 1835-41.

COLORADO.

Within the limits of this history no successful attempt at the establishment of a geological survey seems to have been made. It is true that in 1872 the territorial legislature showed a slight realization of the possible value of such a survey, and a willingness to profit by it provided it cost them nothing. The following is the text of an act passed with this in view:

> *Be it enacted by the council and house of representatives of Colorado Territory:*
>
> SECTION 1. That the governor of the Territory is hereby authorized and empowered to appoint, by and with the advice and consent of the legislative council, a territorial geologist, who shall be commissioned by the governor, reside in the Territory, and hold his office for the term of two years from the date of his appointment.
>
> SEC. 2. No compensation for services, nor for any expenses whatever, shall be paid by the Territory to or for the said territorial geologist.
>
> SEC. 3. The territorial geologist shall report the result of his surveys and observations, made under and by virtue of the commission provided for in section 1 of this act, to the governor of the Territory, to be submitted to the next legislative assembly, on or before the first day of January, A. D. 1874.
>
> SEC. 4. This act shall take effect and be in force from and after its passage.
>
> Approved February 9, 1872.

It is said[1] that under this law J. Alden Smith was appointed State geologist in 1874 and 1881: Ernest LeNeve Foster in 1883; J. Alden Smith again in 1885; Fred G. Buckley in 1887; George E. Kedzie in 1889 and 1893; Thomas A. Ricard in 1897 and 1899; John W. Finch in 1901 and 1903; and B. A. Langridge in 1906. Naturally, in view of section 2, however able may have been the various officials, little was accomplished. Three or four brief reports are said to have been published, but these have long since passed out of print, and are unavailable for reference.

CONNECTICUT.

SURVEY UNDER J. G. PERCIVAL AND C. U. SHEPARD, 1835–1842.

In the annual message of Governor Edwards of Connecticut to the State legislature of 1835 there occurs the following relative to the establishment of a geological survey:

> The mineralogical treasures which have been developed within a few years and which are constantly coming to light in different parts of our country give us reason to believe that we have not as yet availed ourselves to the extent that we might of this source of wealth, and suggests the expediency of a more systematic examination than has hitherto taken place. In some instances this has been done under the public patronage and by public authority. An examination of the kind in our State might lead to some important discoveries. An accurate

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[1] Bulletin 465, U. S. Geological Survey, 1911, p. 24.

and thorough geological and mineralogical survey by scientific men, if it should not result in any immediate discoveries of moment, would at least have the effect of aiding individuals in their future researches on their own lands. Much labor has been expended and money wasted in the search after metals and minerals, which a knowledge of those substances and the relative position they uniformly occupy would have shown to be useless.

The geological character of a country indicates its topographical features, and a geological map would serve as a guide in the examination and selection of routes for railroads and canals and internal improvements of every kind, the location of which depends on the topical features of the country through which they pass. A survey of the kind referred to would furnish every individual with such information respecting his possessions as would guard him against the wiles of prowling speculators. Much labor has been bestowed on this subject, and much information collected by individuals in different sections of the State, and it is important that this information should be embodied and preserved. The expense would be trifling, and bear but a very small proportion to the benefits which may be derived from it. This is a subject in which the whole community has a deep interest, and it is recommended that immediate measures be taken for its accomplishment. Similar surveys have been already had in some of the States, and the attention of others is turned to the subject. Let us not be deficient on our part. We have heretofore furnished, and we can still furnish, our full quota to those economical and scientific researches which seem to be the order of the day.

In accordance with this recommendation, the following resolutions were introduced and passed:

Resolved, That the governor be and is hereby authorized to appoint a committee of suitable persons to make a geological survey of the State of Connecticut and to report the same to the general assembly at their May session of 1836.

Resolved, That the property of such survey shall be in and belong to the State and shall be disposed of as the general assembly may direct.

Pursuant to these resolutions, the Governor made the necessary appointments, as below:[1]

Henry W. Edwards, governor of the State of Connecticut, to James Gates Percival and Charles Upham Shepard, greeting: Pursuant to resolves passed by the general assembly of Connecticut, at Hartford, in May, 1835, I do appoint you, said Percival and Shepard, a committee to make and complete the survey and report in said resolves, to perform the duties thereof, and obey the instructions from time to time received from the proper authority.

Given under my hand and official seal at New Haven, this 15th day of June, A. D. 1835.

HENRY W. EDWARDS.

Field work under these authorizations appears to have been begun at once, and a preliminary report rendered to the legislature of 1836. This was accepted and the necessary authority granted for continuing the survey another year, publication to be delayed until the necessary researches were completed.

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[1] It is said (Bull No. 7, Conn. Geol. and Nat. Hist. Surv., 1907) that the charge of the survey was first offered to Professor Silliman, who declined. Percival and Shepard also at first declined, but finally accepted at the urgent request of Governor Edwards.

Professor Shepard, to whom was assigned the economical and mineralogical part of the work, submitted his report to the legislature of 1837. This gave rise to the following:

Report of the committee on the geological survey.

The joint committee on the geological and mineralogical survey of the State, to whom was referred the special message of the governor and the accompanying papers relating to the mineralogical department of said survey, having had the same under their consideration, report:

That Professor Shepard has brought his examination into the mineralogy of the State to a close and the results of his labors have been before us in a highly interesting and valuable report. This report, embracing the statistics of all our present mineral resources, the condition of our mines, quarries, and diggings of every description, and suggestions as to the most profitable manner of working them both to the proprietors and the public, all of which are capable of immediate application, your committee recommend should be immediately published. This report will attract public attention to the mineral wealth of the State, which is shown to be most abundant, and only stands in need of capital and enterprise to be profitably developed. It will apprise landed proprietors of resources of which in many instances they are now ignorant, and in others will afford them information how to turn to increased account such as they already know to exist. It teaches what things may be expected in certain districts of the State, points out the mode of searching for them, and the way to identify them when found.

Another consideration which should determine its immediate publication is, that it may receive the supervision of Professor Shepard while passing through the press—a supervision altogether necessary from the nature of the subjects treated of, and which it may not be in his power to extend after this summer. For this reason, too, your committee recommend its being published at New Haven, where Professor Shepard resides, and where publishers are more accustomed to this kind of work than elsewhere in the State.

The document will constitute an octavo volume, or pamphlet, of 150 pages, and if published in the style in which these surveys are done in other States will cost about 25 cents a copy. Your committee, therefore, recommend an appropriation of a sum of money not exceeding $500, or such less sum as his excellency the governor may contract for, for the publication of 2,000 copies. That of this number the governor be authorized to distribute copies in the following manner:

Two copies to the Library of Congress; two copies to the governor of every State in the Union; two copies to the library of Yale College of Washington College, and of the Wesleyan University of this State, and to each of the State officers; one copy to each of the judges of the supreme court; one copy to each of the judges of the county court and to each probate judge of this State, who are not members of this legislature; one copy to each member of the two houses of the present legislature; one copy to the town clerk of very town in the State: 50 copies to remain at the disposal of Professor Shepard, and the same number at the disposal of his excellency the governor. And the governor is further authorized to furnish any bookseller such number of copies, to be disposed of on such terms as his excellency may deem proper, for the benefit of the State.

This disposition of this report which your committee have recommended, in case it should be published, will only reach about one-half the number proposed to be printed, and will leave 1,000 copies to be taken up by private sale, or disposed of by the next general assembly.

With these considerations your committee would respectfully recommend the adoption of the accompanying resolution. All of which is respectfully submitted.

James Beebe, *Chairman*.

The above report was accepted and the following resolution passed relative to the publication of the same:

Resolved by this assembly, That 2,000 copies of Professor Shepard's report on the mineralogy of the State be published under the superintendence of the author, and that a sum of money not exceeding $500 be appropriated to defray the expenses; and that the comptroller of public accounts is hereby authorized to draw an order on the treasurer for such sum, not exceeding $500, to be paid out of any money not otherwise appropriated; and his excellency the governor is hereby appointed commissioner to see the object of this resolution effected.

This report, as issued in 1837, comprised 188 octavo pages. It was divided into three parts: 1 Economical, 2 Scientific, and 3 A descriptive catalogue of the rock and mineral collection made during the work, comprising 595 names.

Percival's report, owing to the author's disposition to go into minute details, was delayed from year to year, finally appearing in 1842 in the form of an octavo volume of 495 pages, with a geological map of the State in black and white. According to Shepard, Percival was a martyr to literary and scientific conscientiousness. Not being fully satisfied in his own mind, he refused to make his report to the legislature when such was demanded, but asked for an extension of time. He thus continued his labors from year to year upon a stipend scarcely adequate to cover expenses. Instead, however, of nearing the goal, he only receded from it. New difficulties met him in the work; fresh questions arose in the progress of geology itself that called for re-examinations. His notes swelled to volumes and his specimens increased to thousands. He was in danger of being crushed under the weight of his doubts and materials. At last the people clamored for the end of the work. The legislature became peremptory and forced Percival to acquiesce. In 1842 (seven years from the commencement of the survey) he rendered an octavo report of 495 pages, in the introduction to which he observes:

I regret to say I have not had the means allowed me for additional investigations, nor even for a proper use of my materials, either notes or specimens. The number of localities from which I have collected specimens I have estimated at nearly 8,000; the records of dips and bearings are still more numerous. The report which follows is but a hasty outline, written mainly from recollection, with only occasional reference to my materials and under circumstances little calculated for cool consideration.

Percival's account of his methods of procedure are not without interest. He says:[1]

> I had twice surveyed the whole State on a regular plan of sections from east to west, reducing the intervals in the last survey to an average distance of 2 miles, thus passing along one side of each of the nearly 5,000 square miles of the State. * * * I had examined all objects of geological interest, particularly the rocks and those including minerals, with minute attention. I scarcely passed a ledge or point of rock without particular examination. I had completed 11 manuscript volumes, amounting to nearly 1,500 pages, very finely written in abbreviation. I had collected specimens from at least 8,000 localities, according to a very reduced calculation from actual enumeration of one town, and several specimens from each locality, each specimen intended to illustrate something peculiar and noticed in my notes: all my specimens marked on the papers enclosing them and checked in my notebooks, so that I know their precise locality and could again trace them to the spot where I found them. In all these researches, from the commencement, I had had in view the determination of the geological system of the rocks of the State. All these researches had been a continued process, not only of particular examination, but of comparison and reflection, all tending to the determination of the great system. I say with the confidence of conviction—of that conviction which arises from long-continued devotion to the subject—that I have determined in my mind the system of arrangement; that it is a new system with me, the result of my own unassisted observation, one which I have not traced in my reading, and one which I believe to be of the highest importance, not only to science, but for economical purposes. * * * Besides this more general plan of the survey, I had especially explored and traced out the trap, both connected with the primary and secondary, and determined a new and important system of arrangement, apparently applicable to both, and one, too, of which I have found no traces in my reading. * * *
>
> Up to the session of 1840, I had employed five years on the survey and had received $3,000, averaging $600 per annum, out of which I had defrayed all expenses, traveling expenses included. * * * I was then required to prepare a report, cut off from all resources, deprived of that pittance of $500, which I might have secured two years before almost without additional labor, if I had regarded my own interests only.

According to Professor Dana,[1] Percival, on entering upon his duties, saw before him two great problems:

> First, the character and origin of the trap ridges of the State, such as East and West Rocks near New Haven, the Hanging Hills of Meriden, and other similar heights to the north and south, * * * and, secondly, the characters and origin of the granitic series of rocks which prevail through all the rest of the State.

Percival's observations proved:

> that there had been not one long-continuous fracture through the State from New Haven to the regions of Mt. Tom and beyond, for the injection of liquid trap rock, but instead, a series of openings along a common line, and that there were several such lines running a nearly parallel course over a broad region of country. He also found that the ridges which compose a range do not always lie directly in the same line, but that often the parts which follow one

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[1] Life and Letters of J. G. Percival, by J. H. Wood.

another are successively to the east of one another, or to the west, en echelon (as the French style it); and, further, that the parts of the component ridges of a range were often curved, or a succession of curving lines. He discovered, too, that in the region of the Meriden Hanging Hills the trap ridges take a singular east and west bend across the great central valley of the State—a course wholly at variance with the old notions.

The work which he accomplished was, in the first place, an extended topographical survey of this portion of the State, and, secondly, a thorough examination of the structure and relations of the trap ridges, with also those of the associated sandstone. And it brought out, as its grand result, a system of general truths with regard to the fractures of the earth's crust, which, as geologists are beginning to see, are the very same that are fundamental in the constitution of mountain chains. For this combination of many approximately parallel lines of ranges in one system, the composite structure of the several ranges and the en echelon, or advancing and retreating arrangement of the successive ridges of a range, are common features of mountain chains. The earth's great mountains and the trap ranges of central New England are results of subterranean forces acting upon the earth's crust according to common laws. The State of Connecticut, through the mind and labors of Percival, has contributed the best and fullest exemplification of the laws yet obtained, and thus prepared the way for a correct understanding of the great features of the globe. * * *

Percival pursued his second subject, that of the granitic rocks, with similar fidelity, and mapped out with care the several formations. * * * His labors were not without practical results, for he was the first to explain correctly the origin of the iron-ore beds of Kent and similar beds in the Green Mountain range.[1]

The receipt of this report gave rise to the following resolution:

At the general assembly of the State of Connecticut, holden at New Haven in said State, on the first Wednesday of May, in the year of our Lord one thousand eight hundred and forty-two.

Resolved by this assembly, That not less than 1,000 copies of Dr. James G. Percival's report on the geology of Connecticut be published under the superintendence of the author, and that a sum not exceeding $1,500 be appropriated to defray the expenses of printing and superintending, and that the controller of the public accounts be hereby authorized to draw an order on the treasurer for such sum, not exceeding $1,500, to be paid out of money not otherwise appropriated; and his excellency the governor and Hon. Henry W. Edwards are hereby appointed commissioners to see the object of this resolution effected.

And be it further resolved, That the commissioners before named be authorized to cause the copyright of the said report to be secured to the State and to permit any additional number of copies to be published and disposed of in such

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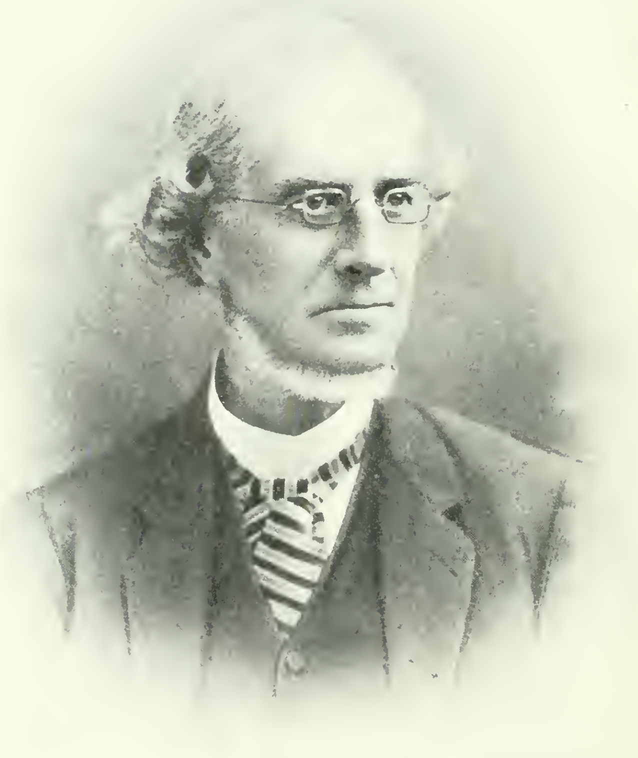
[1] Messrs. Gregory and Robinson, of the present survey (1907), in like manner render appreciative testimony: "Percival's Report on the Geology of Connecticut is not a readable book; it does not contain theories and inferences and bits of lively description, but merely dry facts grouped geographically. It is about the last book which a poet, one of the most celebrated of his time, would be expected to write. Accuracy and keenness of observation and distinctness of representation are, however, prime requisites for lasting scientific work, and in these qualities Percival excelled. The more the modern geologist becomes familiar with the involved structures and exasperating variations found within the metamorphic rocks of the State, the more respect and admiration he has for Percival's discrimination and skill of delineation. It is doubtful if ever a more accurate discrimination of the various members of a complicated series of crystalline rocks on field evidence alone was ever accomplished."



JAMES CURTIS BOOTH

STATE GEOLOGIST OF DELAWARE, 1839-41.

manner and on such terms as they may deem proper, for the benefit of the author: *Provided*, That no additional expense be thereby incurred by the State over and above the sum of $1,500 aforesaid.

Expense.—The resolution establishing the survey makes no references to expenses or appropriations. Nothing is stated as to amount paid Professor Shepard for services, but in the bill of 1837, $500 was appropriated for the publication of his report. Percival, in his lamentations, writes of having received $3,000 in salary, and, as above noted, $1,500 was appropriated for publication. The expense of the survey can then be placed at $5,000, exclusive of Professor Shepard's salary, which it is safe to say was small, if indeed he received anything.

By an act approved June 3, 1903, a second survey, geological and natural history, was established under control of a board of commissioners, with Prof. William North Rice, superintendent. This survey is still in progress.[1]

DELAWARE.[2]

The first and only systematic attempt at a geological survey of Delaware was made in 1837, in virtue of an act of the legislature, of which the following is a transcript:

An act to provide for a geological and mineralogical survey of this State.

SECTION 1. *Be it enacted by the senate and house of representatives of the State of Delaware in general assembly met*, That Thomas Stockton, of New Castle County; Jonathan Jenkins, of Kent County; and Dr. Henry F. Hall, of Sussex County, be and they are hereby appointed commissioners to procure to be made a geological and mineralogical survey of this State. And it shall be the duty of the said commissioners, as soon as practicable after the passage of this act, to appoint a State geologist of talents, integrity, and suitable scientific and practical knowledge of his profession, who shall also be a scientific and practical mineralogist.

SEC. 2. And it shall be the duty of the said State geologist immediately to commence and carry on with as much expedition and despatch as may be consistent with minuteness and accuracy, a geological and mineralogical survey of the State, with a view to determine the order, succession, arrangement, relative position, and the dip or inclination, and also the comparative magnitude of the several strata, or geological formations, within the State, and to discover and examine all beds and deposits of ores, coals, clays, marls, and such other mineral substances as may be deemed useful or valuable, together with such other duties as may be necessary to make a full and complete geological and mineralogical survey of this State.

SEC. 3. And it shall be further the duty of the said State geologist, on or before the first day of January in each and every year during the time necessarily occupied by the survey, to make a report of the progress of the survey, accompanied with such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same, to the secretary of the State of Delaware, who shall lay them before the legislature, at their next meeting thereafter.

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[1] See Bulletin 465, U. S. Geological Survey, 1911.

[2] Compiled in part from manuscript, by J. C. Booth.

SEC. 4. It shall further be the duty of the said commissioners to employ such suitable assistants as may be necessary and proper for the full performance of the duties imposed upon the said State geologist, and also to procure to be made a correct map of this State, and cause to be marked thereon, by colors and other appropriate means, the various areas occupied by the different geological formations in the State, together with the beds or deposits of the various mineral substances discovered; and on the completion of the said survey to compile, or cause to be compiled, a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey, which memoir they shall transmit to the secretary of the State of Delaware, to be by him laid before the legislature at their next meeting thereafter.

SEC. 5. *And be it further enacted*, That the said commissioners be and they are hereby authorized to contract and agree with the said State geologist and assistants for their services upon such terms and for such reasonable compensation as shall seem to them just and proper; and for the payment of such compensation they, by their chairman, are hereby authorized to draw upon the State treasurer, who is hereby required to pay the same out of the moneys appropriated for that purpose.

SEC. 6. *And be it further enacted*, That the said commissioners shall receive for their services the sum of $3 a day each for each and every day that they shall be engaged in the prosecution of the duties hereinafter imposed upon them, to be paid as is hereinbefore directed for the payment of the State geologist and assistants; and it shall be the further duty of the said commissioners to keep a just and true account of their own services as to days on which they are engaged in the performance of their duties herein, as well as by the services performed by the said State geologist and assistants, together with the moneys paid and ordered drawn by them, in furtherance of the objects of this act, which account shall be presented by them to the legislature, for settlement, at the next biennial session after the completion of the said survey.

SEC. 7. *And be it further enacted*, That for the purpose of carrying on and completing the said geological and mineralogical survey, the sum of $3,000 is hereby appropriated, to be subject to the orders of, and expended by, the said commissioners, as hereinbefore directed: *Provided*, That not more than the sum of $1,000 of such appropriation shall be expended in any one county of this State for the purpose of carrying into effect the objects of this act.

SEC. 8. In case of the death or resignation of any one or more of the commissioners herein appointed it shall be lawful for the governor of this State to fill the vacancy thus occasioned by the appointment of such person or persons from the county in which such vacancy may occur as shall in his judgment be suitable and qualified for the appointment.

Dover, Feb'y 13, 1837.

No change or modification in this law was found necessary, the single appropriation of $3,000 being sufficient to cover all expenses, including that of publication. The survey had no connection with any other institution, being established, conducted, and completed under the act above quoted.

Administration.—Under the authority granted the commissioners named in the act of establishment, Dr. J. C. Booth was appointed State geologist in the spring of 1837. No assistants or subordinates were employed. Doctor Booth's salary was at the rate of $1,000 a year, and continued for but two years. From a somewhat superficial survey of the State he decided that, since of the 2,200 square miles included in the State area, 2,000 square miles were devoted chiefly to agriculture, his principal efforts should be directed to this feature of the work. To quote his own words he devoted his time "chiefly to the assumed duties of a traveling instructor in agriculture, without exhibiting the formality of teacher among the people to be taught." The fertilizing resources of the green sand and shell marls were, as a result, given a major share of his attention. No museum nor library was provided for. Such fossils as were collected were placed in the hands of Timothy Conrad and others for identification.

Expenses.—The total cost of the survey, as already noted, was $3,000, of which $2,000 was for salary of Doctor Booth and $1,000 to pay the cost of publication of the report.

Publication.—The report comprised but a single volume of 188 pages, a few hundred copies only being issued, the same being distributed gratis by the commissioners.

Benefits.—The chief benefits of the survey, as stated by Doctor Booth, were:

> After having surveyed the State with sufficient minuteness to describe its geological features, and to point out the then and probable future value of the different geological formations, I devoted the larger portion of the time remaining for the completion of the survey (more than one-half of the whole survey period of two years) to traversing the State in every direction, and personally communicating information on agriculture, and especially on the development of agriculture in each district, by means of the geological advantages offered by such district. I regarded such a result as more important and of greater value to the State than any additions to natural science; and after the experience and reflection of 50 years in the same line of thought, I perceive no good ground or reason to change my views.

FLORIDA.

Until the establishment, in 1907, of a State survey, under the direction of E. H. Sellards, Florida can scarcely be said to have undertaken any systematic geological work at State expense. In the reports of the assembly for 1852–53 is found an act, approved by the governor on January 8, 1853, establishing the office of State engineer and geologist. The act need not be quoted entire. It is sufficient to note that it authorized the general assembly, by joint vote, to elect a State engineer and geologist, who should hold office for the term of two years. The duties, as outlined in the act, were the making of surveys of the swamp lands for the purpose of reclamation. Salary, not to exceed $2,000 a year, and other necessary expenses, were to be paid out of the receipts from the sale of these same swamp lands, or, should these amounts prove insufficient, out of the internal-improvement fund.

Under this act Mr. F. L. Dancy was appointed State engineer and geologist in 1853. It is not apparent that he was a geologist in any sense of the word or that he attempted to do any geological work. His report as State engineer occupies pages 19 to 36 of documents accompanying the message of the governor of Florida, submitted November 28, 1854. All that occurs relative to geology is given on page 20 of the appendix, and reads as follows:

> On the subject of the geology of the State I have made no report, from the fact that the general assembly failed to specify any duties or make any appropriations to defray any expenses incurred in reference to the matter. Consequently, nothing has been done by me except to obtain specimens of soils and minerals from the various localities (where marked changes were perceptible) visited by me in the performance of the duties of engineer.

The office was abolished by an act of the assembly in 1855. Nothing further appears to have been done until 1886, when, on his own responsibility, and evidently without the passage of any enactment by the legislature, Governor Perry appointed Dr. J. Kost, State geologist. Below is a transcript of the letter making this appointment, together with that of a letter given to Doctor Kost, the purpose of which is self-apparent:

EXECUTIVE DEPARTMENT.

In the name and under the authority of the State of Florida.

Whereas Dr. J. Kost has been duly appointed by the governor to make a geological survey of the State of Florida:

Now, therefore, reposing especial trust and confidence in the ability, fidelity, and prudence of the said Dr. J. Kost, I, Edward A. Perry, governor of the State of Florida, under and by the virtue of the authority vested in me, do hereby appoint and commission said Dr. J. Kost to make such survey of the State of Florida, and to have, hold, and exercise all the powers appertaining thereto, and to perform the duties thereof, and to enjoy all the privileges and benefits of the same.

In testimony whereof, I do hereunto set my hand and cause to be affixed the great seal of the State of Florida, at Tallahassee, the capital, this, the first day of January, A. D. 1886, and of the independence of the United States the one hundred and tenth year.

E. A. PERRY, *Governor of Florida.*

By the Governor: Attest.

JANUARY 1, 1886.

To all whom it may concern:

Realizing how important to our State and to all interested in ascertaining and developing its resources that there should be a thorough geological survey of Florida, and recognizing that in the absence of a legislative appropriation

George Little, 1874-81

William Smith Yeates, 1893-1908

Joseph William Winthrop Spencer, 1890-93

STATE GEOLOGISTS OF GEORGIA.

therefor I should be powerless to institute such an undertaking but for the liberal offer of Dr. J. Kost to make such survey free of all cost to the State, provided that he be furnished with transportation for himself and one assistant for the purpose, I have cheerfully accepted Doctor Kost's generous proposition. and respectfully bespeak for him such facilities and cooperation from the transportation lines of the State and from the people as it may be in their power to extend to him. All such courtesies will be highly appreciated.

Respectfully,

E. A. PERRY, *Governor*.

It is evident that Kost's services were wholly gratuitous, although the writer is informed that certain sums were paid for freight and labor on collections intended for museum materials. The records however, show no payment for geological work.[1]

Kost made one report, entitled First Report of the Geological Survey of Florida. This was issued in 1887, and was in form of a pamphlet of 31 pages, but contained little of value. In May, 1889, the following resolution was passed by the State assembly, but with no appreciable effect:

Joint resolution memorializing Congress for a continuation of the geological survey of the State of Florida.

Whereas the work done by the United States geologist in the State of Florida has shown surprising promise in value, in the truthful, instructive, and necessary information concerning the geology of our State; and

Whereas the work has been discontinued; therefore—

Be it resolved by the legislature of the State of Florida, That we deem it of the greatest importance to our State that such surveys should be continued to completion: to that end our Senators and Representatives in Congress be and they are hereby requested to use all effort to procure the immediate resuming and continuance of said work, and for that purpose Congress is hereby memorialized.

Approved May 7, 1889.

GEORGIA.

FIRST GEOLOGICAL SURVEY UNDER JOHN R. COTTING, 1836–1840.

With a view to attracting the attention of the legislature to the importance of a geological and agricultural survey of the State "the patriotic citizens of Burke and Richmond Counties, at their own individual expense," in 1835 directed John Ruggles Cotting

to make a geological and agricultural survey of their respective counties; to examine all localities of limestone, marls, and other minerals useful in agriculture and the arts; also rocks that may be proper for the purposes of architecture, the construction of roads, railways, etc.; to examine the water of springs and wells with regard to the salubrity or nonsalubrity of the same; to analyze the soil on different plantations in the two counties with a view to their improvement; to illustrate the whole by drawings, diagrams, and a chart of the two counties, and to present a report of the same to his excellency the governor.

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[1] I am indebted to State Geologist E. H. Sellards for the above information.

This to be done in order that the matter might come properly before the two branches of the legislature.

In conformity with these instructions Mr. Cotting began his survey March 21, 1836, at a place called Shell Bluff, on the Savannah River, in Burke County, and continued his investigations until both counties were completed. His results were published in the form of a small octavo volume of 128 pages, bearing the date 1836.

This laudable attempt on the part of Mr. Cotting and the citizens of Burke and Richmond Counties was only partially successful. The immediate result was the passage by the senate of the following resolution, which was approved on the 7th of December, 1836:

> The committee appointed on that portion of the governor's message which relates to a geological survey of the State of Georgia say they have given the same due consideration and ask leave to make the following report:
>
> That they feel sensible that this is a subject entitled to the most favorable consideration of the legislature at this time, not only from the importance of developing the resources of Georgia as they are connected with the arts, the agricultural, the mining, and the manufacturing interests of this State, but from the further consideration that she is bound to contribute her share with those States who have engaged in a similar enterprise to the cause of science and the diffusion of that information that can not but be useful to our sister States and that of the whole country. Your committee believe that perhaps no State of the Union is more interested in such an examination than Georgia; with a most extensive territory, reaching from the marshes of the seacoast and pine forests to the Appalachian Mountains, traversing a large extent of country of every variety of location and soil, containing localities doubtless affording the most important means of enriching and restoring her impoverished and barren lands; a subject most intimately connected with the interests of agriculture, whilst the arts and manufactures will find ample materials for their enterprise and profit. Your committee believe that new articles of commerce will be developed for the employment and enriching our citizens.
>
> The extensive mining region of the western portion of our State, known, as they are, to contain extensive and rich deposits of gold and other important metals, furnish strong incentives to this undertaking. That our citizens may not waste their resources in irregular and unscientific experiment much may be done by the employment of one suitable and scientific individual, or more, who shall furnish such facts and lay down such principles as will enable them to direct their capital and enterprise with greater security against losses and disappointments so well calculated to check the spirit of enterprise.
>
> Intimately connected with this subject is the great interests of internal improvement, whether by means of our navigable rivers or inlets or by means of railroads. The streams of the State, with their extent and capabilities of navigation, the ridges, mountains, and general (fertility) of the country, with its capacity for agriculture and commerce, it is high time that Georgia, with all her treasures, in money and resources, should, forgetting party bickering and strife, make an effort to raise herself to that exalted station among her sister States to which she is entitled by the extent and fertility of her territory, the ample resources of commercial and agricultural enterprise, her favorable location in reference to the other States, and the energy and intelligence of her citizens. Your committee, therefore, beg leave to report the following resolutions.

Resolved, That his excellency the governor, or his successor in office, be, and he is hereby, authorized to employ, as soon as convenient, one or more suitable and well-qualified persons to undertake the work of a careful and scientific geological survey of all the counties in Georgia, under his direction and advice.

And be it further resolved, That the sum of $10,000 ought to be appropriated for that purpose, subject to the warrant of the executive, out of any moneys in the treasury not otherwise appropriated, and said sum be inserted in the appropriation act of this year.

Resolved further, That the geologist so appointed shall keep an office at the seat of government, where he shall preserve, for the use of the State, the various specimens connected with the survey, and shall remain at the seat of government during the greatest part of the session of the legislature. He shall make an annual report of the progress of the work to the governor, and at the termination of his survey he shall prepare from his journals and reports, a consolidated report for publication, to be handed over to the governor, and the copyright secured to the State, and make returns semiannually to the governor.

In senate, agreed to, December 7, 1836.

ROBERT M. ECHOLS,
President of the Senate.

Although so favorably inaugurated, however, nothing seems to have been accomplished,[1] and on December 11, 1840, the survey was suspended and finally abolished through the following enactment:

In House of Representatives.

Whereas the creation of the office of a geological surveyor of this State involves the State in an annual expenditure of several thousand dollars, without producing any adequate advantage to the people thereof:

Be it therefore resolved by the Senate and House of Representatives of the State of Georgia, in general assembly met, That the said office of geological surveyor of this State be, and the same is, hereby abolished.

Agreed to, November 27, 1840.

The matter seems, however, to have come up later for reconsideration, in the senate, with the following result:

In Senate.

Whereas John R. Cotting has in contemplation (and has partly prepared) to publish a complete report of the agricultural and geological survey of all the counties in this State; and

Whereas nearly half the State has been surveyed, and an immense amount of matter collected and contained in the journals of said John R. Cotting, together with a variety of drawings; and

Whereas the most interesting portion of Georgia remains yet to be examined, and the results of his future investigation is necessary to prevent the total loss of all his past labors and expenditures.

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[1] S. W. McCallie writes: (Bull. 465, U. S. G. S., pp. 37–38) that a report was rendered in 1837 covering the counties of Chatham, Columbia, Effingham, Screven, Burke, Richmond, Lincoln, Elbert, Franklin, Habersham, and part of Wilkes and Oglethorpe. This, however, was never published.

Therefore, be it resolved by the Senate and House of Representatives of the State of Georgia in general assembly met, That his excellency the governor be, and he is hereby, authorized to allow John R. Cotting the full and entire use of the geological department of this State, together with all the instruments, apparatus, and privileges appertaining to the same, so far as may be necessary for completing the geological survey of this State at his expense.

And be it further resolved, That John R. Cotting be allowed to continue the geological and agricultural survey of this State, and retain the title of State geologist, without any compensation from the State.

And be it also resolved, That the copyright reserved to the State be, and the same is hereby, vested in John R. Cotting.

Agreed to, December 18, 1840.

The printed records do not show that the passage of these resolutions was productive of any results. It is not known to the writer what became of Cotting's notes, nor is it apparent why the survey was abandoned.

SECOND GEOLOGICAL SURVEY UNDER GEORGE LITTLE, 1874–1879.

The second attempt at a systematic survey of the State, under State auspices was undertaken in 1874, under the conditions enumerated below:

An act to create the office of State geologist, and to provide for a geological, mineralogical, and physical survey of the State of Georgia, and for other purposes.

Whereas the State of Georgia contains valuable deposits of iron, coal, copper, gold, and other minerals, numerous water powers, and other undeveloped sources of wealth; and

Whereas the true value of these resources, representing the natural wealth of Georgia, has not been determined by scientific examination and made known to the public; and

Whereas an accurate and mineralogical and physical survey of the State, made by competent, scientific authority, and published under the sanction of the State, would, by its general distribution, make known the superior advantages of Georgia, and hence by attracting immigration and capital, add greatly to the development and wealth of the State; therefore—

SECTION I. *Be it enacted, etc.,* That the office of State geologist of the State of Georgia is hereby created; that the governor, as soon as practicable after the passage of this act, shall nominate a competent person to this office, to be confirmed by the senate, who shall hold his office until removed by the appointing power for inefficiency, incompetency, or misconduct, or until abolishment of the office by the general assembly. The office of the State geologist shall be at the seat of government.

SEC. II. *Be it enacted,* That, in connection with the office named in the first section of this act, there shall be a board of advisement, with the governor as its president, to consist of the governor, secretary of state, comptroller general, treasurer, attorney general, and State school commissioner.

SEC. III. *Be it enacted,* That the State geologist shall have two competent assistants, to be chosen by the board, who shall be at any time removed by the appointing power for the like causes for which the State geologist may be removed. It shall be the duty of the State geologist and his assistants forthwith to map out the State into three geological sections, as nearly equal in area as possible, to be known as north Georgia, middle Georgia, and south Georgia geological sections. So soon as a general outline of geological survey of the entire State shall have been made the State geologist shall enter upon one of these sections, and assign one to each of his assistants; and, under the control of the first named, the corps shall proceed to make a careful and complete geological, mineralogical, and physical survey of the State; to enter upon records, to be kept for that purpose in his office, an accurate statement of the locality and extent of all water powers, woods, roads, springs, and watercourses, and the climate and general physical condition of the country; to collect, analyze, and classify specimens of minerals, plants, and soils, and enter the same on record; to cause to be preserved in a museum specimens illustrating the geology, mineralogy, soils, plants, valuable woods, and whatever else may be discovered in Georgia of scientific or economic value. For the purpose of making the analysis here contemplated the State geologist shall have access to the chemical laboratory of the State University. The State geologist shall have the supervision of the entire work and shall be responsible for the accuracy and thoroughness of the same.

Sec. IV. *Be it enacted*, That the board of advisement shall have the supervision of the money expenditures in the prosecution of the work contemplated by this act. The State geologist shall make to the governor monthly statements, under oath, of all incidental expenses necessarily expended by himself and his assistants in and about the discharge of their labors. The governor shall lay this statement before the board, who shall allow or reject the account, as in their judgment may be right. When an account is allowed the governor shall draw his warrant for the amount thereof upon the fund appropriated by the provisions of this act. The governor, with the advice and consent of the board, may at any time suspend the field operations of the geological corps until the next meeting of the general assembly.

Sec. V. *Be it enacted*, That the State geologist shall make the governor an annual report of all information developed in the progress of his work, and the governor shall lay the same before the general assembly.

Sec. VI. *Be it enacted*, That the salary of the State geologist shall be $2,000 per annum, and that of his assistants $1,200 per annum each.

Sec. VII. *Be it enacted*, That the sum of $10,000, or so much thereof as may be necessary, is hereby appropriated, annually, for five years, to carry the provisions of this act into effect.

Sec. VIII. Repeals conflicting laws.

Approved February 27, 1874.

This act was subsequently amended, as noted later.

Under the act of 1874, Dr. George Little was appointed State geologist at a salary of $2,000 a year and A. R. McCutcheon and W. S. Schley assistants at salaries of $1,200 a year each. These assistants were chosen by the board of advisement. In addition, D. C. Barrow was put in charge of the survey office at Atlanta, while the services of W. J. Land as chemist and C. A. Locke as civil engineer were also secured.

The field work was begun September 16, 1874, in accordance with the plan of the original enactment. The first brief report of 30 pages, giving the results of the work up to December 31, 1874, shows that the chief efforts were directed toward economic results.

In this report Doctor Little called attention to the fact that, in order to satisfactorily meet the demands of the citizens of the State, the corps of the survey should be increased. The following amendment to the law was therefore passed and approved on February 27, 1875:

An act to amend An act to create the office of State geologist, and to provide for a geological, mineralogical, and physical survey for the State of Georgia, approved February 27, 1874, and further to define the duties of the State geologist and his assistants, and for other purposes therein mentioned.

SECTION I. *Be it enacted by the General Assembly of the State of Georgia,* That from and after the passage of this act, and as soon as the State geologist shall have performed the duties required in the third section of the act entitled "An act to create the office of State geologist, and to provide for a geological, mineralogical, and physical survey of the State of Georgia, and for other purposes," approved February 27, 1874, and that it shall be the duty of the State geologist and of his assistants therein named to commence the prosecution of their duties on the eastern or western boundary of the State, taking in each of the sections to be known as north, middle, and south Georgia, the most easterly or westerly tier of the counties in these respective sections, and to examine, survey, and report upon the same, in accordance with the requirements of the provisions of said act; and afterwards to take the next most easterly or westerly tier of counties running from north to south, and so on, until all the counties in each one of the three sections in this State shall have been fully surveyed, examined, and reported upon, as is provided for in said act creating the office of State geologist.

SEC. II. *The general assembly do enact,* That section 3 of said original act be, and the same is hereby, amended by striking out first clause of said section and inserting in lieu thereof, "that the State geologist shall have three assistants, to be appointed or removed by the board of advisement on his recommendation"; and that said section be further amended by striking from the tenth line the words, "enter upon one of these sections," and so that said section, when amended, shall permit said State geologist to assign one assistant to each geological section of the State, he having general supervision of the whole work.

SEC. III. *The general assembly do enact,* That section 6 of the original act, approved February 27, 1874, be, and the same is hereby, repealed.[1]

SEC. IV. Repeals conflicting laws.

Approved February 27, 1875.

Under this amendment the following organization was effected:

Northern division: A. R. McCutcheon, LaFayette, Walker County, geologist; M. T. Singleton, Kingston, Bartow County, engineer.

Middle division: D. C. Barrow, jr., Woodville, Oglethorpe County, geologist; C. A. Locke, Decatur, DeKalb County, engineer.

Southern division: R. H. Loughridge, Atlanta, Fulton County, geologist; C. C. Terry, Columbus, Muscogee County, engineer; W. S. Schley, of Savannah, Chatham County, in charge of office; W. J. Land, of Atlanta, Fulton County, chemist; and Prof. F. H. Bradley,

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[1] The section (VI) of the original act prescribed the pay of the geologist and assistants.

Nacoochee, White County, geologist and special surveyor of the gold region and the Blue Ridge.

During 1875, 105 of the 137 counties of the State were visited, and data collected sufficient, as announced in the second annual report, to permit the working out during the winter months of "the general geology of the whole State, and to construct a map approximately correct, on which most of the useful minerals can be noted and many of the roads and water powers. We are now prepared," Doctor Little announced, "to enter upon the detailed, systematic and accurate survey of each county in the several divisions of the State; and it is proposed, during the next season, to begin this work at three points on the western border of the State." The plan was not, however, carried out, owing presumably to insufficient time, the survey being abolished by the following resolution, in 1881:

> Whereas the general assembly of Georgia, by act approved February 27, 1874, did provide for a geological survey of the State and did create the office of State geologist, making an appropriation of $10,000 per annum for five years, and no longer, for the purpose of carrying out the provisions of said act; and
>
> Whereas said term of five years did expire in the year 1879, and said appropriation was not extended or continued, the act of 1874 being thus allowed to expire by its own limitations, the general assembly of 1879 directing, by joint resolution, approved October 17, 1879, the governor to turn over to the commissioner of agriculture all the material of said geological department, and further requiring the governor to sell all the chemicals, live stock, and camp equipage of said department, thereby giving notice to the world that said geological survey was ended and said office of geologist abolished; therefore,
>
> *Be it resolved by the General Assembly of Georgia*, That said office of State geologist was discontinued and abolished in the year 1879 by the facts above recited, and that the said geologist has no claim on the State for any salary as such geologist since that date.
>
> Approved September 28, 1881.

Expenses.—The salary of the State geologist was fixed by law at $2,000 a year and those of his assistants at $1,200 a year. The expense of publication of the second report was provided for by a special appropriation of $500. The total expense of the survey, as shown by the appropriations, would appear to have been:

As provided by act of 1874, $10,000 a year for five years	$50,000
For printing	500
For chemicals	500
	$51,000

Publications.—Two brief annual reports in the form of pamphlets of 36 and 16 pages, respectively, constitute the entire official results of the survey, though in Jones's Handbook of the State of Georgia, 1876, pages 17 to 143 are occupied with an account of the geology of the State, which is accredited to Little, as is also a catalogue of ores, rocks, and woods selected for the Paris Exposition. By a resolution dated February 26, 1877, the edition of the report of the geologists was fixed at 5,000 copies.

Museum.—Although the wording of the original act would seem to have contemplated the formation of a museum, no definite steps in that direction appear to have been taken. In the final resolution for the abolition of the survey it was provided that all the material of the survey, aside from live stock and camp equipage, should be turned over to the commissioner of agriculture.

THIRD GEOLOGICAL SURVEY UNDER J. W. SPENCER AND W. S. YEATES, 1889–1900.

From the time of cessation of work by Doctor Little until November, 1889, the State survey seems to have been dormant. On the 12th of that month the following act was passed and approved:

An act to revive the office of State geologist, and to provide for a geological, mineralogical, and physical survey of the State of Georgia, and for other purposes.

SECTION I. *Be it enacted by the General Assembly of Georgia*, That the office of State geologist is hereby revived, and the governor, as soon as practicable after the passage of this act, shall appoint, with the consent of the advisory board, a competent person to this office, who shall have a thorough, scientific, and practical knowledge of the science of geology and mineralogy, and who is not connected with any school or college as an instructor. The State geologist shall enter upon the duties of his office on the 1st day of July, 1890, and shall hold until removed by the appointing power for inefficiency, incompetency, or misconduct, or until the office is abolished by the general assembly. The office of the State geologist shall be at the seat of government.

SEC. II. *Be it further enacted*, That there shall be an advisory board, consisting of the governor of the State (who shall be president of the board), the commissioner of agriculture, the State school commissioner, the State treasurer, the comptroller general, and the attorney general. Four members present at any meeting shall constitute a quorum for the transaction of any business.

SEC. III. *Be it further enacted*, That two competent assistant State geologists shall be chosen by the advisory board, who may be removed at any time, by the appointing power, for incompetency, inefficiency, or misconduct. It shall be the duty of the State geologist and his assistants to divide the State into three geological sections, as nearly equal in area as may be expedient, to be known as North Georgia, Middle Georgia, and South Georgia geological sections; the northern section shall extend from the State line southward to the thirty-fourth degree of latitude; the middle section shall extend from that degree southward to the thirty-third degree of latitude; the southern section shall extend from the last-mentioned degree to the southern boundary of the State line; the survey and exploration of each of said sections shall commence simultaneously by said State geologist and his assistants; and $1,000 of the foregoing appropriation, or so much thereof as may be necessary, shall be applied to each of said sections for an outfit and necessary expenses incident to the prosecution of the work in each section. So soon as a general outline of geological survey of the entire State shall have been made, the State geologist shall enter upon one of these sections, and assign one to each of his assistants; and, under the control of the first named, the corps shall proceed to make a careful and complete geological, mineralogical, and physical survey of the State; to enter upon record, to be kept for that purpose in his office, an accurate statement of the extent of all water powers, woods, roads, springs, and watercourses, and the climate, topography, and general physical character of the country, and locate the belts of ores and useful minerals, building material; report characteristics and composition of soils, and the deposits of marls and phosphates; to collect, analyze, and classify specimens of minerals, plants, and soils, and enter the same upon record; to cause to be preserved in a museum specimens illustrating the geology, mineralogy, soils, plants, valuable woods, and whatever else may be discovered in Georgia of scientific or economic value, and shall make a report of the survey of every county of this State, accompanied with all necessary maps and illustrations. For the purpose of making the analysis contemplated in this act, the State geologist shall have access to the chemical laboratory of the State. The State geologist shall have supervision of the entire work, and shall be responsible for the accuracy of the same. It shall be the duty of the State geologist to make reports to the advisory board as often as required by them, and they shall report to each general assembly the progress and condition of the survey; an accurate account of money spent; and such reports of the State geologist and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

Sec. IV. *Be it further enacted*, That the advisory board shall have the supervision of the money expenditures in the prosecution of the work contemplated by this act. The State geologist shall make to the advisory board monthly statements under oath of all incidental expenses necessarily incurred by himself and his assistants, accompanied by proper vouchers, in the discharge of their labors. The board shall audit such accounts, item by item, and approve or reject the same, as in their judgment may be right. When an account is allowed, the governor shall draw his warrant for the amount thereof upon the funds appropriated by the provisions of this act. The governor, with the advice and consent of the board, may, at any time, suspend the field operations of the geological corps until the next meeting of the general assembly.

Sec. V. *Be it further enacted*, That the State geologist shall keep his office in a room to be set aside for that purpose by the governor, and the commissioner of agriculture shall furnish the clerical work required by the State geologist.

Sec. VI. *Be it further enacted*, That the salary of the State geologist shall be $2,500 per annum, and the two assistants shall each receive a salary of $1,250 per annum, to be paid as now provided by law for the payment of other state house officers.

Sec. VII. *Be it further enacted*, That the State geologist, with the consent of the board of advisement, may employ a specialist, or specialists, at any time.

Sec. VIII. *Be it further enacted*, That neither the State geologist nor his assistants shall disclose to any person, except to the owner of the land, the result of a survey, until the same is made public by publication of the report by the advisory board, which shall be monthly or quarterly.

Sec. IX. *Be it further enacted*, That the State geologist and his assistants shall deposit, in the office of the governor, all maps, surveys, notes, or memorandum of surveys, when the surveys are completed, which are hereby declared to be the property of the State.

Sec. X. *Be it further enacted*, That the sum of $8,000, or so much thereof as may be necessary, be, and the same is, hereby appropriated, annually, for the period of five years, to carry out the purposes of this act, and this appropriation shall take effect annually, commencing on July 1, 1890.

SEC. XI. *Be it further enacted*, That all laws in conflict with this act are hereby repealed.

Approved, November 12, 1889.

Administration.—Under this law J. W. Spencer was appointed State geologist, entering upon his duties July 1, 1890. C. C. Anderson, a civil engineer, was put in charge of the hydrographic work of the survey and E. T. Whatley appointed assistant geologist, the assistants being appointed, according to the text of the law, by the governing board.

The salary of the State geologist was fixed at $2,500 a year and that of his assistants at $1,250 a year. Doctor Spencer remained in office until 1893, when he was succeeded by W. S. Yeates,[1] under whom the following have from time to time served as assistants: F. P. King, S. W. McCallie, George E. Ladd, Thos. L. Watson, as geologists; R. L. Packard and Walter L. Mitchell, chemists, the salary remaining as under Doctor Spencer.

Publications.—During Doctor Spencer's administration two reports were published, one termed Administrative, but devoted quite largely to the geology of the Cretaceous and Tertiary formations of the southwestern part of the State; and the other issued under date of July 1, 1891, entitled The Paleozoic Group, comprising some 400 pages and including the geology of 10 counties of the northwestern portion of the State and their economical resources.

Museum.—A very satisfactory exhibit of the mineral and economic products of the State has been built up and is now on display at the statehouse.

Expenses.—The expense of the survey, aside from cost of publication, would appear to have been fully met by the appropriation authorized in the bill of November 12, 1889—$8,000 a year for the ensuing seven years (1889–1896), and $10,000 a year since that date. The average cost of publication of the bulletins is given as $3 a page with 22½ cents additional a volume for cloth bindings. At present the cost of publication is met by an annual appropriation of $2,500.

ILLINOIS.

FIRST GEOLOGICAL SURVEY UNDER J. G. NORWOOD, 1851–1858, AND A. H. WORTHEN, 1858–1880.

The first geological survey of Illinois was organized under an act of the general assembly approved February 17, 1851. The following is the text of the act:

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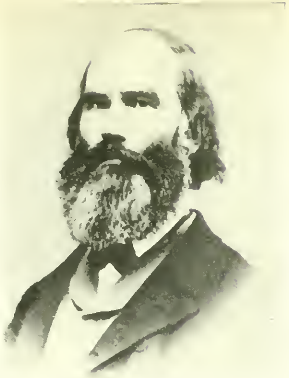
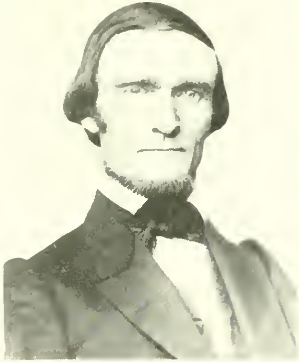
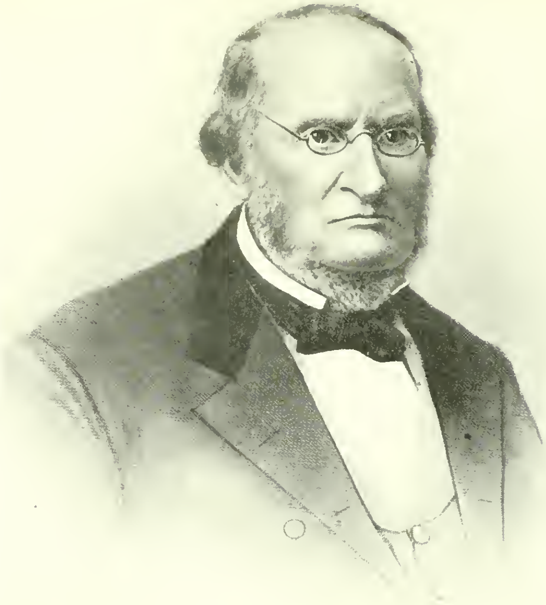
[1] Mr. Yeates died on February 19, 1908, and was succeeded by S. W. McCallie, who still holds the office. (See Bull. 465, U. S. Geol. Surv., 1911.)



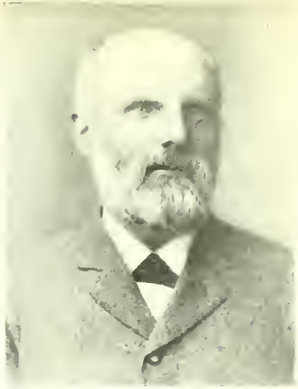
AMOS HENRY WORTHEN,
GEOLOGIST, 1858-72



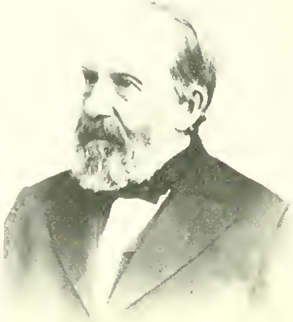
FIELDING BRADFORD MEEK,
PALEONTOLOGIST



JOSEPH GRANVILLE NORWOOD, 1851-58



HENRY ENGELMANN,
PALEONTOLOGIST



LEO LESQUEREUX,
PALEO BOTANIST

STATE GEOLOGISTS OF ILLINOIS.

An act for a geological and mineralogical survey of the State of Illinois.

SECTION 1. *Be it enacted by the people of the State of Illinois, represented in the General Assembly,* That the governor, auditor, and treasurer of the State are hereby authorized and required, as early as may be, to employ a geologist of known integrity and practical skill for the purpose of making a geological and minerological survey of the entire territory of this State.

2. It shall be the duty of said geologist to proceed, as soon as the necessary arrangements can be made, and with as much despatch as may be consistent with minuteness and accuracy, to ascertain the order, succession, arrangement, relative position, dip, and comparative magnitude of the several strata or geological formation within the State; to search for and examine all the beds and deposits of ores, coals, clays, marls, rocks, and such other mineral substances as may present themselves, and to obtain chemical analysis of these substances, the elements of which are undetermined; and, by strict barometrical observations, to determine the relative elevations and depressions of the different parts of the State.

3. It shall also be the duty of said geologist, during the time employed in the above work, to make annual reports of the progress and results of his labor, accompanied by such maps and drawings as may be deemed necessary to illustrate the said reports; all of which shall be transmitted to the governor, in such condition as he may, without delay, cause them to be printed and circulated throughout the State or wherever else he may desire to send them.

4. It shall be the duty of said geologist to procure and preserve a full and entire suite of the different specimens found in the State, and cause them to be delivered to the secretary of state, who shall cause them to be properly arranged in a cabinet, and deposited in some apartment in or convenient to the capitol. Said suite shall be sufficienly large to furnish specimens to all institutions of learning within the State, empowered to confer degrees in the arts and sciences.

5. The final reports of said geologist shall embody the results of the entire survey, and shall be accompanied by a geological map of the State, showing, by different colors and other marks and characters, the precise localities and extent of the different geological formations.

6. For the purpose of carrying out and completing the said survey the sum of not exceeding $3,000 is hereby placed at the disposal of the governor, to be applied to the payment of the said geologist, and such assistants as he may employ, by and with the consent of the governor, auditor, and treasurer, and to defray the incidental expenses of the survey; which annual appropriation shall continue until the completion of said survey, or until its discontinuance be ordered by the legislature of this State.

7. No money shall be paid to said geologist or for the purpose of said survey until the work shall be commenced.

8. The said survey shall, if practicable, be commenced at the southern part of the State and be proceeded with northerly.

This act to take effect and be in force from and after its passage.

Approved, February 17, 1851.

In 1853, and again in 1872, this law was supplemented and amended by the passage of the following:

That the sum of $5,000 be, and the same is, hereby annually appropriated for the purpose of carrying out and completing the geological and mineralogical survey of the State of Illinois; and also the further sum of $500 per annum, for the purpose of furnishing accurate topographical maps of the several counties in the State, to be made out under the direction and superintendence of the State geologist. The said sums of money are hereby placed at the disposal of the governor, to be applied by him to the uses and purposes specified in this act and the act to which this is an amendment.

An act providing for the publication and distribution of the fifth volume of the report of the State geologist and to fix the amount of his salary until the publication of the sixth and final volume of said report.

SECTION 1. *Be it enacted by the people of the State of Ilinois, represented in the general assembly.* That the publication of 3,000 copies of the fifth volume of the report of the State geologist is hereby authorized, and the sum of $6,500 is hereby appropriated to defray the cost of engraving the necessary plates, maps, and diagrams required for said volume; said engraving to be done under the direction of the State geologist, who first obtain bids for doing the work from several different engravers, and submit such bids to the governor, who shall first approve the bid most favorable to the State, and order the geologist to make a contract on the terms of said bid.

2. The secretary of state is hereby required to procure the paper necessary for the said fifth volume, of a quality not inferior to that used in the volumes of this report already published, and have said volume printed under the State contract for public printing, and bound by the public binder in same style and quality as former volumes, at a rate to be fixed, before delivered to him, by the secretary, auditor, and treasurer, with the aid of experts, as now provided by law; and the amount necessary to defray the expense of the same is hereby appropriated.

3. The secretary of state is hereby authorized to distribute the said fifth volume, when published, as follows: One copy to each college, educational, historical, and literary institution in the State, as now provided by law; 200 copies to the State geologist, to be used in exchanges, a list of which shall be submitted to the governor for his approval, and on all such copies for exchange shall be written or printed " With the compliments of the people of the State of Illinois," and the person's name to whom sent; and the balance of said volumes to the members of the twenty-seventh general assembly, to be by them distributed in their respective counties and districts, as far as practicable, to persons who have sets of the former volumes.

4. There shall be paid to the State geologist the sum of $2,000, as in full for his services and all expenses in superintending the publication of the said fifth volume, and finishing the sixth volume for publication; to be paid quarterly out of any money in the State treasury not otherwise appropriated.

Approved, April 3, 1872.

That portion of the act of 1851 relating to the preservation of suites of specimens not proving sufficiently explicit, was later amended so as to read as below:

An act to amend an act entitled "An act for a geological and mineralogical survey of the State of Illinois," approved February 17, 1851.

SECTION 1. *Be it enacted by the people of the State of Illinois, represented in the general assembly,* That section 4 of "An act for a geological and mineralogical survey of the State of Illinois," approved February 17, 1851, be, and the same is hereby, amended, so as to read as follows:

4. It shall be the duty of said geologist to procure and preserve a full and entire suite of the different specimens found in the State, and cause them to be delivered to the secretary of state, who shall cause them to be properly arranged in a cabinet, and deposited in some apartment in or convenient to the capitol. Said suite shall be sufficiently large to furnish specimens to all institutions of learning within the State which are empowered to confer degrees in the arts or sciences, to the State normal schools, to the industrial university at Champaign, and to all chartered institutions of science located in this State which publish their proceedings and which keep up a regular system of exchanges with other like institutions.

Approved, April 29, 1873.

It is evident from the wording of the original act of establishment that the formation of a library was not contemplated, though in the third clause of the act of April 3, 1872, reference is made to copies of the reports "to be used as exchanges." Presumably a considerable amount of material must have accumulated, the growing importance of which, together with the importance of the geological collections, caused the passage of the following full and explicit act, which resulted in the establishment of the existing State historical and natural history museum:

An act to establish a State historical and natural history museum; to provide for its care and maintenance, and to appropriate money therefor. Approved May 25, 1877. In force July 1, 1877.

Whereas it is important and desirable that all books, manuscripts, and other matters illustrative of the early history of this State shall be preserved in some permanent form; and

Whereas the collection of geological specimens accumulated in the progress of the geological survey of this State are lying in a disorganized mass in the basement of the capitol; and

Whereas the large and valuable collection of specimens of zoology and botany in the museum of natural history at Normal are now in a building not fireproof, and therefore in danger of destruction by fire: therefore—

10. *Established.*—1. *Be it enacted by the people of the State of Illinois, represented in the general assembly,* That there is hereby established at the capitol of the State a State historical library and cabinet of natural history, to be known as "The Illinois State Historical Library and Natural History Museum."

11. *Rooms in statehouse.*—2. The rooms in the west wing of the statehouse, known as the miscellaneous library rooms, are hereby set apart for the said library and museum established by this act.

12. *Management—Trustees.*—3. The Illinois State Historical Library and Natural History Museum shall be under the management of three trustees, consisting of the governor, secretary of state, and superintendent of public instruction, who shall have power to make all such rules and regulations, not inconsistent with law, as may be necessary for its management.

13. *Curator.*—4. It shall be the duty of said trustees to appoint a curator, who shall be a person of competent scientific attainments, and who shall possess a practical knowledge of the science of geology.

14. *Curator to be the librarian.*—5. The curator shall act as librarian and shall have the custody, superintendence, and charge of all articles directed to

be deposited in said library and museum, and shall also perform the acts which are or may be required by law of the State geologist.

15. *Curator to select certain books.*—6. It shall be the duty of the said curator, as soon as the statehouse commissioners furnish the bookcases and furniture designed for the galleries of said rooms, to select from the State library all books and documents relating to the history of this State and place them in the new rooms as a nucleus for a State historical library.

16. *Geological specimens to be removed and classified.*—7. It shall be the duty of the curator as soon after this act takes effect as is practicable, to have the collection of geological specimens accumulated in the progress of the geological survey of this State, and other specimens hereinafter named, removed to said rooms and classified, labeled, and arranged in such a manner as to be effectually preserved and at the same time open to the inspection of the public.

17. *Duplicate specimens.*—8. One each of all the duplicate zoological and botanical specimens now on hand in the Illinois museum of natural history at Normal, which are not needed to illustrate the natural history work of the State Normal University, are hereby directed to be deposited as soon as practicable in the museum established by this act by the curator of said Illinois Museum of Natural History.

18. *Museum at Normal.*—9. It is hereby directed that the Illinois Museum of Natural History at Normal be converted into a State laboratory of natural history, at which, under the direction of the curator thereof, the collection, preservation, and determination of all zoological and botanical material for said State museum shall be done. It is made a part of the duty of said curator to provide, as soon as possible, a series of specimens illustrating the zoology and botany of the State, to deposit them from time to time in the museum established by this act, and to furnish as far as practicable, all zoological and botanical material needed by the State educational institutions for the proper performance of their work.

19. *Appropriation.*—10. For the purpose of carrying out the provisions of this act, the following named sums are hereby appropriated out of the State treasury for the purposes herein specified:

For the salary of the curator provided for in this act, the sum of $2,500 per annum for two years, payable quarterly.

For the purpose of moving the geological specimens from the basement, and of moving the natural history specimens at Normal to the rooms designated, and for arranging, classifying, labeling, and putting all the said specimens in such condition that they will be effectually preserved and at the same time open to the convenient inspection of the public, the sum of $500.

For the purpose of increasing the collections in natural history, the sum of $1,000 per annum, to be expended under the direction of the curator of the State laboratory at Normal.

20. *When and how drawn.*—11. The auditor of public accounts is hereby authorized and required to draw his warrant on the treasurer for the moneys herein appropriated, upon the order of the board of trustees: *Provided*, That no portion of said moneys, other than the annual salaries, shall be due and payable until satisfactory vouchers in detail shall have been filed with the auditor for the expenditures incurred.

The survey, as will be noted by reference to these various enactments, had no connection with any other institution and was sustained wholly by legislative appropriations, at first annual and later biennial.

Administration.—Under the act of 1851 Dr. J. G. Norwood was appointed State geologist and J. H. McChesney, Henry Pratten, Anthony Varner, and A. H. Worthen, assistants. In March, 1858, A. H. Worthen became State geologist, and H. M. Bannister, F. H. Bradley, E. T. Cox, Henry Engelmann, H. C. Freedman, H. A. Green, J. H. McChesney, and Frank Snow, assistants in geology, with W. Billington, topographer. Leo Lesquereux, F. B. Meek, J. S. Newberry, and Orestes St. John were assistants in paleontology.[1]

According to the terms of the law, assistants were appointed only with the consent of the governor, auditor, and treasurer. The salaries paid the directors varied at different periods from $2,000 to $3,000 a year; those of the assistants in geology, from $800 to $1,000; and those of the paleontologists from $1,200 to $1,800. Topographers received but $500 a year.

Museum.—Section IV of the act of 1851 called for the making of collections to be delivered to the secretary of state, who should "cause them to be properly arranged in a cabinet and deposited in some apartment in or convenient to the capitol." It was stipulated also that the collection should be sufficiently large to furnish specimens to all institutions of learning within the State empowered to confer degrees in the arts and sciences. In 1873 this clause, as noted, was so amended as to include the State Normal Schools, the Industrial University at Champaign, and all chartered institutions of science located in the State and which published their proceedings and kept up a regular system of exchanges with other like institutions.

Publications.—Doctor Norwood remained in charge of the survey until the spring of 1858, during which time he published two brochures, the first in connection with Henry Pratten in 1855, which consisted of 77 pages of text and three plates. This appeared in the Journal of the Academy of Natural Sciences of Philadelphia. The second, entitled Abstract of a Report on Illinois Coals, with description and analyses, and a general notice of the coal fields, contained 93 pages of text and was published in Springfield in 1857.

Under Worthen's administration the first and second volumes of the final report were published in 1866, the third in 1868, the fourth in 1870, the fifth in 1873, the sixth in 1875, the seventh in 1883, and the eighth in 1890. These volumes contained detailed reports of all the counties of the State and as much of the paleontology as the time and means at the disposal of the director enabled him to complete.

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[1] The statements made on p. 43 of Survey Bulletin No. 465, relative to E. O. Ulrich, is somewhat misleading, since the survey came to an end in 1872, as noted. It was not until 1885 that Mr. Ulrich was employed by Mr. Worthen, then curator of the State Museum, to complete volume 8 of the reports of the defunct organization, an appropriation for which had been made by the legislature of that year.

The Paleozoic rocks of the State, especially the upper and lower Carboniferous formations, proved to be exceedingly rich in fossil remains, and the whole of the second and a portion of each succeeding volume of the reports was devoted to the description and illustration of the new forms discovered in the prosecution of the work of the survey. One hundred and ninety-five octavo plates and numerous woodcuts were required to properly illustrate the species described in the first six volumes.

The editions of the various reports were exhausted in a few months after publication, and as there was a continued demand for them at the office of the secretary of state, the thirty-first general assembly passed an act in 1881 authorizing a reprint in three volumes of the economical portion of the six volumes previously published, and also requiring the curator of the museum to prepare and publish another volume of geology and paleontology to correspond in form and style with the six originals, to be entitled: Volume 7 of the Geological Survey of Illinois. Five thousand copies of this volume were authorized and 3,000 copies each of the three volumes of economic geology. These three volumes were issued in 1882, and volume 7, containing 31 plates, the following year.

The publications of the survey were distributed partly by the general assembly, each member receiving five copies, and the remainder by the secretary of state, except 300 copies, which were given to the authors of the work for foreign distribution.

Benefits.—The material results of the survey of Illinois have been the correct determination of the coal resources of the State, by defining the extent, number, and thickness of the different coal seams; a full report on the lead regions of both the northern and southern part of the State; also pointing out the location and extent of other mineral products, such as building stone, hydraulic, and common limestones, clays for pottery, firebrick, paint, etc. Its contributions to science have been the discovery, description, and illustration of nearly 1,200 new or little known species of fossils and the publication of a geological map of the State on a scale of 6 miles to the inch.

The development of the coal resources undoubtedly gave a decided impetus to nearly all industrial interests, and in consequence of the cheap and abundant fuel resources, steel and iron mills and extensive zinc works have been established. The same cause has stimulated railroad enterprise and added vastly to the value of the prairie lands which, before the coal resources were known, were considered as of little value, in consequence of the scarcity of fuel.

As noted in the laws, the survey was abolished in 1872, though appropriations for completing the publications were continued until

1875, when all active work ceased for a period of 30 years, to be revived once more in 1905.[1]

Expenses.—The following summary of appropriations for the geological survey, 1851–1875; the Historical Library and State Museum of Natural History, 1877–1889; and for the State Museum of Natural History, 1889 to 1900, is furnished by Mr. C. H. Crantz, curator:

1851.	Seventeenth General Assembly: Survey instituted and a sum not to exceed $3,000 a year appropriated	$6,000.00
1853.	Eighteenth General Assembly: General appropriation, a year, $5,000; for topographical maps, a year, $500	11,000.00
1855.	Nineteenth General Assembly appropriation: Same amounts	11,000.00
1857.	Twentieth General Assembly appropriation: Same amounts	11,000.00
1859.	Twenty-first General Assembly appropriation: Same amounts	11,000.00
1861.	Twenty-second General Assembly appropriation: Same amounts	11,000.00
1863.	Twenty-third General Assembly appropriation: Same amounts, and $500 a year, rent of storeroom for collections	12,000.00
1865.	Twenty-fourth General Assembly appropriation: Same amounts, and $20,000 for publishing reports, vols. 1 and 2	32,000.00
1867.	Twenty-fifth General Assembly appropriation: For salary, geologist, a year, $3,000; survey, a year, $10,000; publishing 3,000 copies, vol. 3, $5,000	31,000.00
1869.	Twenty-sixth General Assembly appropriation: Salary, geologist, a year, $3,000; illustrating and publishing vol. 4, $7,500; completing drawings, vol. 5, $1,500	15,000.00
1871.	Twenty-seventh General Assembly appropriation: Salary, geologist, a year, $2,000; publishing and illustrating vol. 5, $6,500	10,500.00
1873.	Twenty-eighth General Assembly appropriation: Salary, geologist, a year, $2,500; salary, assistant, a year, $500; salary, assistant, a year, $600; moving collections, $125; drawings for vol. 6, $1,500; illustrating and publishing vol. 6, $7,500; special appropriation for payment of claim for binding of vols. 1 and 2, $7,636.18	23,961.18
1875.	Twenty-ninth General Assembly made no appropriations for the maintenance of the survey.	
1877.	Thirtieth General Assembly passed act to establish a State historical library and State museum of natural history. Appropriated—salary, curator, a year, $2,500; increasing collections, a year, $1,000; moving collections, $500	7,500.00
1879.	Thirty-first General Assembly appropriation: Salary, curator, a year, $1,800; contingent fund, a year, $300	4,200.00
1881.	Thirty-second General Assembly appropriation: Salary, curator, a year, $2,000; salary, assistant, a year, $600; contingent fund, a year, $300; preparing vol. 7, general reports, and vols. 1, 3 of economic geology, $5,000; printing and binding of 5,000 copies of vol. 7 and 3,000 copies of vols. 1, 3, economic geology, $5,000	15,800.00

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[1] Bull. 465, U. S. Geol. Surv., pp. 42–51.

1883. Thirty-third General Assembly appropriation: Salary, curator, a year, $2,000; salary, assistant, a year, $600; salary, janitor, a year, $600; contingent fund, a year, $300; museum cases, $1,000	$8,000.00
1885. Thirty-fourth General Assembly appropriation: Preparing vol. 8 for publication, $5,000; salary, curator, a year, $2,000; salary, assistant, a year, $600; salary, janitor, a year, $900; contingent fund, a year, $300; for increasing zoological and archaeological collections, $3,000 a year	18,600.00
1887. Thirty-fifth General Assembly appropriation: Salary, curator, a year, $2,000; salary, assistant, a year, $800; salary, janitor, a year, $900; contingent fund, a year, $300	8,000.00
1889. Thirty-sixth General Assembly appropriation: Salary, curator, a year, $2,000; salary, assistant, a year, $1,000; salary, janitor, a year, $900; contingent fund, a year, $300	8,400.00
The Thirty-sixth General Assembly passed act separating the historical library and State museum.	
1891. Thirty-seventh General Assembly appropriation: Salary, curator, a year, $2,500; salary, assistant, a year, $1,000; salary, janitor, a year, $900; contingent fund, a year. $500	9,800.00
1893. Thirty-eighth General Assembly appropriation: Salary, curator, a year, $2,500; salary, assistant, a year, $1,000; salary, janitor, a year, $720; contingent fund, a year, $500	9,440.00
1895. Thirty-ninth General Assembly appropriation: Same amounts	9,440.00
1897. Fortieth General Assembly appropriation: Same amounts	9,440.00
1899. Forty-first General Assembly appropriation: Same amounts	9,440.00
Total	$303,521.18

In this total are not included the cost of office supplies, such as ink, pens, papers, envelopes, etc., furnished direct by the secretary of state.

INDIANA.[1]

FIRST SURVEY UNDER DAVID DALE OWEN, 1837–1838.

The first geological survey of Indiana, under State auspices, was made under the authorization of the following:

Act to provide for a geological survey of the State of Indiana.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That the governor be, and he is hereby, authorized and required annually hereafter to appoint and commission a person of talents, integrity, and suitable scientific acquirements, as geologist for the State of Indiana, who shall receive in consideration of the faithful performance of his duties an annual salary not exceeding $1,500, and necessary expenses not exceeding $250, to be paid as the salaries of other civil officers of State are or may be directed to be paid.

SEC. 2. That it shall be the duty of the geologist to be appointed as aforesaid to make a complete and minute geological survey of the whole State, commencing with those portions in the vicinity of the contemplated public works (always having reference to the directions hereinafter provided), and thence through the other portions of the State, with as much expedition and accuracy as may be

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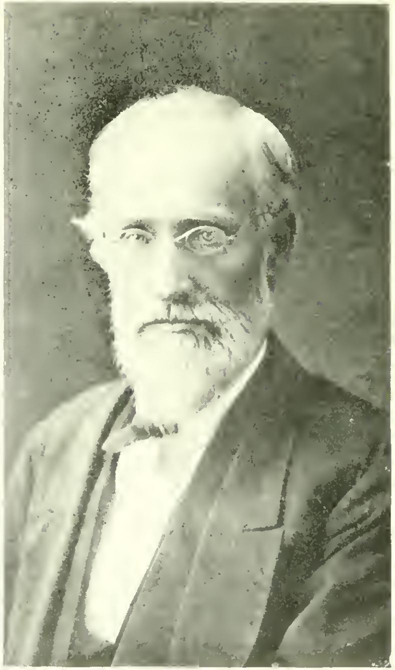
[1] Compiled in part from manuscripts by Dr. Ryland T. Brown and Prof. Richard Owen.

RICHARD OWEN, 1860-62

EDWARD TRAVERS COX, 1868-80


JOHN COLLETT, 1880-84

STATE GEOLOGISTS OF INDIANA.

consistent with minuteness and dispatch, and he shall prepare and lay before the legislature, at the commencement of every session, a detailed account of all remarkable discoveries made and the progress of the work, accompanied with proper maps and diagrams, including a geological chart of the State.

Sec. 3. It shall further be the duty of the geologist of the State, at those seasons not suited to active prosecution of the geological survey, to analyze and ascertain the qualities and properties of mineral substances or soils left at his office or residence for that purpose by any citizen of the State and taken from any proportion of the territory of the State.

Sec. 4. That the said geologist, appointed by virtue of this act, shall be subject to the orders of the executive of the State, and shall hold himself ready on reasonable notice to make geological examinations in the vicinity of internal improvement which the legislature has or may hereafter direct to be made: *Provided*, That this act shall expire at the termination of the year 1838, unless the same be reenacted by the next legislature of this State.

Sec. 5. This act to be in force from and after its passage.

Approved February 6, 1837.

Dr. David Dale Owen, by this act, was appointed State geologist and made a reconnoissance of the State, takng a general view of the several formations and designating, with a fair amount of accuracy. the boundary of the coal fields. According to manuscript notes by Dr. Richard Owen he had no assistants. He made his own field observations (traveling on horseback), and his chemical analyses in his laboratory at New Harmony. No topographical work was attempted. He made but one report, which was issued in two parts in 1838, when he resigned to accept an appointment under the General Government. Owing to the financial depression, 1838–1840, no successor was appointed, and the survey came to an end.

In 1850 the subject of a survey was once more brought up, and the following resolutions passed, though without apparent effect:

A joint resolution upon the subject of a grant of land for a geological survey of the State of Indiana.

Whereas, a large part of the mineral lands in the State of Indiana belong to the United States, and their value consists chiefly in the minerals under the surface that are not so easily to be ascertained without a geological survey of the district in which they lie; and whereas, the people of this State desire the direct and indirect advantages that would grow out of the development and use of these minerals and deem it justice that the General Government should contribute its fair proportion to the cost of bringing its own lands into market: wherefore—

Section 1. *Be it resolved by the General Assembly of the State of Indiana*, That our Senators in Congress are hereby instructed and our Representatives requested to use their exertions to procure a grant of a township of land, or its equivalent, of the unsold lands of the United States in Indiana for the purpose of aiding the State in making a full geological survey thereof.

Sec. 2. *Be it further resolved*, That his excellency the governor be requested to transmit a copy of this joint resolution to each of our Senators and Representatives in Congress.

Approved January 21, 1850.

In 1852 the matter came up once more in a similar form, and the following joint resolution passed, though again with no apparent result:

A joint resolution in relation to a donation of public lands for a geological, agricultural, and topographical survey.

Be it resolved by the General Assembly of the State of Indiana, That our Senators in Congress be instructed and Representatives requested to use their votes and influence to effect the passage of a law giving to the States, respectively, in which there is so much unsold public land, one township in each landoffice district, to be applied by the proper authorities of the State for the purpose of making a geological, agricultural, and topographical survey of such State; and

Be it further resolved, That his excellency the governor be and is hereby authorized to furnish each of our Senators and Representatives a copy of this joint resolution; also one copy to each of the governors of the several States, and request them to lay the same before the legislatures.

Approved January 12, 1852.

In 1853 Gov. Joseph A. Wright, in his message to the legislature, urged the resumption of the geological survey in order to develop the mineral resources of the State. In response to this there was made, according to the manuscript notes of Dr. Ryland T. Brown, a small appropriation which became available in January, 1854. To expend this the governor appointed Doctor Brown State geologist. One report was made on the work of the season of 1854. This the legislature refused to publish on the ground that it conveyed an erroneous and exaggerated idea as to the value of the coals of the State. Appropriation for the continuation of the work was also refused. Doctor Brown's suppressed report, it should be stated, was subsequently published in the reports of the Department of Agriculture.

SECOND GEOLOGICAL SURVEY UNDER D. D. OWEN AND RICHARD OWEN, 1859–1861.[1]

The subject of a survey coming again before the legislature, in 1859, the following enactment was passed:

An act authorizing the State board of agriculture to cause a geological reconnoissance of the State to be made, to make collections and analyses of specimens, and making appropriations therefor.

Whereas the State board of agriculture has memorialized the general assembly for such aid a full geological survey of the State would give in furtherance of the object for which said board was organized; and

Whereas the finances of the State are not now in a condition which would justify such an appropriation as would carry out the plan contemplated by the memorialists; and

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[1] Prepared in part from manuscripts by Dr. Ryland T. Brown and Prof. Richard Owen.

Whereas it is now believed that the sum of $5,000, granted by the State to said board, together with such voluntary contributions as might be made to it, would be sufficient to make a geological reconnoissance of the State and the determination of the general boundaries of its geological formation and also to make collections and analyses of specimens of minerals, ores, earths, and stone from every portion of the State, and thus prepare the way for a more full and systematic survey to be made hereafter under the direction of the State executive; therefore—

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That the sum of $5,000 is hereby appropriated out of the State treasury, and to be paid on the warrant of the auditor to the said State board, for the purpose of making the geological reconnoisance, collections, and analyses of specimens of minerals, ores, earths, and stones: *Provided*, That one-half of said sum shall not be paid prior to April 15, 1860, and the other half not before the 15th of October, 1860.

SEC. 2. The governor is hereby directed to select a convenient room in the capitol, or in any building that may be erected by the State, if a suitable one can be found, and, if not, hire one for the deposit and safe-keeping of such minerals, soils, ores, fossils, maps, sketches, etc., as may be collected and made by direction of said board, which room shall be placed under the control of said board.

SEC. 3. The State board of agriculture shall, on or before the 15th of December, 1860, make a full report to the governor of the expenditures of said appropriation, with full vouchers thereof and of the results accomplished thereby. The governor shall have 2,000 copies of said report printed for the use of the next general assembly.

Organization.—Under this law Dr. D. D. Owen, then State geologist of Arkansas, was for the second time appointed State geologist of Indiana, and his brother, Richard Owen, assistant. Doctor Owen dying shortly after the work was begun, Richard Owen became State geologist, holding the position until 1861, when he resigned to take command of a regiment of volunteers in the Federal Army. The vacancy then created was not filled, and thus the third attempt at a geological survey of the State came to an end.

This survey had no connection with any institution other than the board of agriculture, and was sustained during its brief existence by the single appropriation of $5,000. Section 3 of an act approved May 11, 1861, however, made the State geologist a member of the faculty of the State University, and directed that in the progress of the work he collect specimens of geology and mineralogy in duplicate and deposit one set of the same in the university cabinet.

Administration.—The Owens were assisted on this survey by Dr. Robert Peter, chemist; Leo Lesquereux, botanist; and J. P. Lesley, topographical engineer, the State geologist, himself, being appointed by the State board of agriculture, and the assistants by Doctor Owen. No promotions were made during the existence of the survey. The salaries were at the rate of $8 a day for State geologist; $4 a day for assistants; and from $1.50 to $2 for labor. No salaries were received from other institutions.

Museum.—A considerable amount of material was collected which was deposited in the State collection at Indianapolis, forming thus, the beginnings of the present State museum. No library was attempted.

Expenses.—The total cost of the survey, as already noted, was $5,000, which included salaries, traveling expenses, transportation of specimens, analyses, and a large part if not all of the expenses of printing and engraving.

Publications.—The single report published was printed in 1862 at Indianapolis, in the form of an octavo volume of 368 pages. The edition is stated to have been but 300 copies, 25 of which were placed at the disposal of the State geologist to be distributed as he desired. The entire cost of publication is given in Prof. Richard Owen's notes as about $600, or $2 a copy.

The following notes, in the handwriting of Professor Owen are not without interest as showing his method:

> The object of the reconnoissance by railroad in the autumn of 1859 was to give such a general idea of the general geology and of the important localities to be visited as would render our survey of 1860 more efficient and economical of time and money. Printed circulars were sent in advance to the different members of the board for distribution, informing farmers, who had specimens to exhibit or soil for analysis exactly how to proceed and where to deposit them. At my request Doctor Clapp made tridaily observations at North Albany with his standard cistern barometer, so as to enable me to correct for meteorological changes in making hypsometrical observations.
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> The analytical and office work performed at New Harmony was all under the direction of Dr. D. D. Owen while he lived; the methods were the result of his long experience. As mentioned in the prefatory letter, page 7 of my report, he designed to give some general observations on agricultural chemistry and milk sickness, particularly the connection of the latter with peculiar geological formations.
>
> In addition to the objects above enumerated which were kept in view during the survey I may mention that in connection with general observations regarding the soil of any region, its fertility, etc., I noted the predominance of any given forest tree, such as oak growth, prevalence of beech, etc. (e. g., see report, p. 208, also p. 36). These notes I could take as we passed along, without even stopping the carriage. In arranging them in the report, each subject being under a separate heading, any information wanted could be readily reached by turning to the county and consulting under its appropriate heading the subject required. The lists of fossils in a given locality or formation were always arranged according to their zoological sequence or classification (e. g., report, p. 39). Perhaps the typical section on page 47, as a means of understanding other sections, may be mentioned here.
>
> Some of the above methods I give under this head, as they may perhaps claim to be improvements on the earlier systems. Under this head may perhaps also be mentioned some synopses of classification translated from the French: 1,

Brongniart's Ferns; 2, Milne Edward's Corals and Classification of Animal Kingdom; 3, (English) Woodward's Classification of the Mollusca; 4, A suggestive table of my own of Divisions and Subdivisions of Time and Vertical Space; 5, a map of Wyandotte Cave, after carrying my barometer through and obtaining a topographical survey record from the proprietor.

I sent every specimen collected, unless a duplicate was needed, for further examination and description to Indianapolis, where I suppose they can still be found in the State collection. One remarkable specimen I may mention was found, on being weighed at the nearest Adams Express office, to be 153 pounds and about 3 feet across its base.[1] It was the framework or skeleton of a single community of polyp first described by Hall as *Favistella stella* [sic], but considered by Edwards and Haine as *Columnaria alveolata*. It is just at the junction between lower and upper Silurian, and fine specimens can be found at the deep cut near Madison, Ind. But this large specimen had become detached and rolled to the foot of a considerable hill. It being in the form of a cone we turned it with its face or base upon two rails, and aided by my assistant, Mr. James Patterson, of Jeffersonville, Ind., we carried it to the top of the hill, where we found a wagon going to the railroad station, on which we loaded it.

Later State geologists added to the State collection or museum at Indianapolis, which was in the geological rooms of Prof. Collett in the old statehouse, now, however, I believe pulled down.

The $5,000 appropriation for the survey was expended for per diem of the several officers and employees for traveling expenses, transportation of minerals and fossils, analysis, printing and engraving report, etc. An accurate and separate account was kept and rendered at brief intervals to the State board of agriculture. I remember the secretary expressing his astonishment that I should have gone so much into detail as to mention each 5 cents' worth of milk obtained at the farm houses, if we happened to camp near one.

The entire sum was, I think, the result of a single appropriation, and as far as I remember included the printing and engraving. Of this, however, I am not quite certain, for I remember when I was in Camp Morton (see p. 302 of the report) as colonel of the 60th Indiana Volunteers, guarding the 4,000 prisoners taken at Fort Donelson, I called on Governor Morton with reference to the illustrations (wood cuts from my sketches), and I *think* obtained some addition from a contingent fund for the engraver.

Benefits.—1. The analyses of the soils; the disenchantment of individuals who had "married a gold mine," by proving to them that it was a bed of sulphur and iron; the calculations made for some who desired to sink shafts, and actually found coal within a few feet of the depth indicated (this occurred at West Franklin and elsewhere); the dissuasion from expending money for an artesian well near an anticlinal axis; and much information of a similar character imparted to the citizens of Indiana during the survey and by the publication of the report, may perhaps entitle this survey to the claim of having benefited the citizens of Indiana.

2. As regards the benefit to science, although perhaps not much that was new may have been presented, yet this survey paved the way for others, in which fine block coal, porcelain clay, and clay for terra cotta were pointed out, etc. Had more time and means been at our disposal I think we could have accomplished work that would have been creditable, but the war interfered for a time with all such pursuits, and I was invited by our war governor (the late Senator Morton) to take a military commission and aid in endeavoring

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[1] For a fuller description see p. 49 of the Report on Franklin County.

to convince the South that State rights too strictly interpreted meant disintegration of the Union. Acceding to his wishes I closed my connection with the State board of agriculture and with the second Indiana geological survey.

THIRD GEOLOGICAL SURVEY UNDER E. T. COX, JOHN COLLETT, AND OTHERS, 1869–1900.

In 1869 the subject of a renewal of the survey came before the legislature and the act passed of which the following is a transcript:

An act providing for a geological survey and for the collection and preservation of a geological and mineralogical cabinet of the natural history of the State of Indiana, creating the office of State geologist, defining his duties, and fixing his salary.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That a department of geology and natural science is hereby established in connection with, and under the control and direction of, the Indiana State board of agriculture, for the collection and dissemination of information in relation to geological and other scientific investigations to be made, as hereinafter provided for, for the promotion of agriculture, mining, the arts, and manufactures.

SEC. II. *And be it further enacted*, That the governor is hereby authorized to appoint a suitable person as State geologist to take charge of said department; and said geologist shall hold his office for a term of two years and till his successor shall be appointed as aforesaid, with an annual compensation of $1,800, to be paid in quarterly payments; and, in addition to his salary, said geologist shall be paid also for the necessary traveling expenses incurred while engaged in prosecuting the field surveys, and for chemical reagents used in the analytical work.

SEC. III. *And be it further enacted*, That said State geologist shall have a thorough practical knowledge of geology and analytical chemistry, and shall establish his office at Indianapolis, in the State of Indiana, in a room or rooms furnished to him, free of charge, by the Indiana State board of agriculture; and he shall be required also to supply himself, free of cost to the State, with all the apparatus necessary to fit up an analytical laboratory adapted to making chemical analyses of soils, ores, metals, mineral waters, and other substances that may be thought of value or general interest to the citizens of the State.

SEC. IV. *And be it further enacted*, That said State geologist shall, from time to time make a survey of a portion of the State, in order to be able to complete a thorough geological survey of the whole State as soon as consistent with his other duties as herein defined; and it shall be his duty also to collect, properly label, and arrange in the agricultural rooms specimens of the ores, coals, building stones, clays, soils, and organic remains, quadrupeds, birds, reptiles, fishes, crustacea, mollusca, insects, and all other objects of natural history peculiar to the State, and, as far as practicable, of other States and countries also.

SEC. V. *And be it further enacted*, That the State geologist shall also be required to make annual reports to the Indiana State board of agriculture embracing the full results of his labors for each year, which reports shall be published along with the proceedings of the said State board of agriculture.

SEC. VI. *And be it further enacted*, That, in order to carry the provisions of this act into effect, the sum of $5,000 be, and the same is hereby, annually appropriated out of any funds in the treasury not otherwise appropriated, and placed in charge of the Indiana State board of agriculture for their disbursement in accordance with the provisions herein made and provided for; and it shall be the duty of the State geologist to file with the State board of agriculture, a statement accompanied with the proper vouchers for all moneys expended by him in carrying out the provisions of this act.

SEC. VII. *And be it further enacted*, That there shall be printed and bound annually in a separate volume 2,500 copies of the report of the State geologist, to be printed and provided by law for printing, binding, and distributing the laws and journals.

This act shall be in force from and after its passage.

Approved March 5, 1869.

At the session of 1879 the legislature revised this law and created a bureau of statistics and geology. The following is the text of this act:

An act providing for the establishment of a State bureau of statistics and geology, creating the office of the chief of such department, defining his duties, providing for the collection of statistics on agriculture, manufactures, commerce, education, labor, social, and sanitary subjects, making said chief, curator of the geological cabinet, and appropriating money to carry out the provisions of the act.

SECTION 1. *Be it enacted by the General Assembly of the State of Indiana*, That a department of statistics and geology is hereby established for the collection and dissemination of information, hereinafter provided, by annual printed reports made to the governor and legislature of the State.

SEC. 2. The governor is hereby authorized to appoint, as soon after the passage of this act as convenient, and thereafter biennially, some suitable person to act as chief, who shall have power to employ such assistants as he may deem necessary, and said officer and assistants shall constitute the Indiana bureau of statistics and geology, with headquarters to be furnished by the State: *Provided*, That such chief of the bureau of statistics shall be an expert in the sciences of geology and chemistry.

SEC. 3. The duties of said bureau shall be to collect, systematize, tabulate, and present in annual reports, as hereinafter provided, statistical information and details relating to agriculture, manufacturing, mining, commerce, labor, education, social and sanitary conditions, vital statistics, marriages, and deaths, and to the permanent prosperity of the productive industry of the people of the State.

SEC. 4. It shall be the duty of the several city, incorporated town, county and township assessors, trustees, officers of school boards, and boards of health in their respective cities, towns, counties, and townships; the agents or superintendents of all manufacturing, mining, and mechanical establishments; the managers and superintendents of all corporations, manufacturing, mechanical, and transportation companies and associations; and county superintendents of schools, to make reports and answer questions relating to the duties of said bureau, upon such blanks as may be furnished to them for such purposes by said bureau. And the chief of said department shall have power to administer oaths, to examine witnesses under oath on questions relating to production, manufacturing, mining, transportation, labor, wages, savings, and respecting such other matters as relates to the duties of said bureau.

SEC. 5. The chief of said bureau shall be the curator of the geological cabinet, museum, chemical laboratory, apparatus, and library, and shall from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains, and other objects of natural history peculiar to the State and other States and countries.

Sec. 6. The annual compensation of the chief of said bureau shall be $1,200, to be paid out of the treasury of the State as provided by law for similar expenditures; and in addition thereto the sum of $2,500 be, and the same is hereby, annually appropriated, out of any funds in the State treasury not otherwise appropriated, for two years, to be expended, or so much of it as may become necessary, in the discretion of the chief of said bureau, in carrying out the purposes of said department, as herein provided. It shall be the duty of the chief of said department to render annually to the governor a detail statement, accompanied with the proper vouchers, for all moneys expended by him in carrying out the provisions of this act: *And provided further*, That no greater expenditure of money, or liability therefor, shall be made or incurred by the chief of said bureau, or his assistants, than the sum herein appropriated for carrying into effect the provisions of this act.

Sec. 7. Any person or persons authorized by the bureau to collect statistics or answer questions relating thereto, who shall neglect or refuse to make true returns, as provided for in this act, shall forfeit and pay a fine not exceeding $200.

Sec. 8. The fines arising under this act may be recovered in any court of competent jurisdiction, by information or complaint of the attorney general, and the same shall accrue to the State and be paid into the treasury thereof.

Sec. 9. The act approved March 5, 1869, establishing a separate department of geology, and the acts amendatory thereof and in conflict herewith are hereby repealed.

Sec. 10. Whereas an emergency exists for the immediate taking effect of this act it shall therefore take effect and be in force from and after its passage.

Again, in 1881, the law relating to surveys was revised and a department of geology and natural history created. The following is the text of this law:

An act to provide for the establishing of a department of geology and natural history in this State.

Section 1. *Be it enacted by the General Assembly of the State of Indiana*, That a department of geology and natural history is hereby established for the purpose of continuing the geological and scientific survey of this State, of discovering and developing its natural resources, disseminating information in regard to its agricultural, mining, and manufacturing advantages.

Sec. 2. That the governor shall appoint a competent and suitable person, who shall be skillful in geology and natural science, as State geologist, and who shall be the chief of said department; and said chief shall have power and be authorized to call to his assistance such help as he may deem necessary, but in no case to exceed the amount of expenditure authorized by the general assembly. Said State geologist, when commissioned by the governor, shall take an oath of office as other officers, and shall serve for a term of four years; but said State geologist may be removed by the governor for cause and a successor appointed in his stead, and the governor shall fill any vacancy which may occur from any cause. The compensation of said State geologist shall be $1,800 per year, which shall be paid as other salaries are required by law to be paid.

SEC. 3. It shall be the duty of said State geologist to continue the geological survey of the State, by counties or districts, and to complete and revise the same as may be practicable. He shall give special attention to the discovery of minerals, stones, or other natural substances useful in agriculture, manufacture, or the mechanical arts; he shall be curator of the geological cabinet, museum, apparatus, and library, and shall from time to time, as may be practicable, add specimens to the cabinet of minerals, organic remains, and other objects of natural history peculiar to this State and other States and countries.

SEC. 4. The offices of the geological department shall be in such rooms as may be assigned for this purpose, and he shall keep such office and the State museum open during the usual business hours of other offices of State when not engaged in field or other work requiring his absence therefrom.

SEC. 5. The State geologist shall make to the governor an annual report of his labors and discoveries, and of all useful information he may have obtained in such service, including such descriptions and figures in geology, paleontology, and archeology as may promote science and aid in the diffusion of knowledge; and 5,000 copies of such report shall be printed and published in like manner as other official reports.

SEC. 6. An appropriation of $5,000 annually shall be, and is hereby, made for the next succeeding two years, which shall include the salaries of the State geologist and his paid assistant; and if any part thereof shall remain unexpended it shall remain a part of the general fund of the State, to be used as other general funds of the State are used.

SEC. 7. All acts and parts of acts inconsistent herewith are hereby repealed.

SEC. 8. Whereas an emergency is hereby declared to exist for the immediate taking effect in this act, it shall, therefore, take effect and be in force from and after its passage.

Administration.—Under the enactment of 1869 Prof. E. T. Cox was appointed State geologist, with F. H. Bradley and Dr. Rufus Haymond as assistants, Dr. G. M. Levette acting chemist. In 1870 Dr. John Collett was added to the corps of assistant geologists and made a survey of Sullivan County, and Professor Cox examined Martin County. In 1871 Messrs. Cox and Collett surveyed Daviess County. In 1872 additional assistants were appointed, and B. C. Hobbs made a survey of Parke County; R. B. Warder, of Ohio, Switzerland and Dearborn counties, and John Collett of Pike County. In 1873 W. W. Borden spent the season in the examination of Clark and Floyd counties. In the same year John Collett made a survey of Warren, Lawrence, Knox, and Gibson counties, and Doctor Levette made a cursory examination of Dekalb, Steuben, Noble, Elkhart, St. Joseph, and Laporte counties. In 1874 Jackson County was surveyed by Professor Cox; Brown County by Professor Collett; Scott and Jefferson by W. W. Borden. An elaborate report on the fishes of Indiana was presented by Prof. D. S. Jordan, and a full report of the flora of Jefferson County was made by Prof. J. M. Coulter. In 1875–76 Vigo and Huntington counties were examined by E. T. Cox; Jennings and Ripley counties by W. W.

Borden; Orange County by Dr. M. N. Elrod and S. McIntire; Vandenburg, Owen, Montgomery, and Clay counties by John Collett; and a hydrographic survey of certain small lakes in the northern part of the State was made and reported upon by Doctor Levette. In 1877 Professor Cox made a survey of Wayne County, and in 1878 Harrison and Crawford counties were surveyed and reported upon by John Collett.

Under the act of 1879 John Collett was appointed statistician and geologist, but with an appropriation of only $4,000 a year for the work of both departments and only $505 of which was expended on geology during the year 1879–80. G. K. Greene was appointed as assistant geologist and made a survey of Monroe County. In 1880 Professor Collett made a survey of Putnam County.

Under the act of 1881 Mr. Collett was appointed by the governor as chief geologist for a period of four years. As assistants in the field he appointed Drs. A. J. Phinney, M. N. Elrod, and R. T. Brown. To Doctor Phinney was assigned the survey of Delaware County; to Doctor Elrod, Bartholomew County; and to Doctor Brown, Fountain County; the geologist in chief devoting himself to the survey of Shelby County.

In 1882 the force of field geologists was increased by the addition of D. S. McCaslin, the assignments being as follows: To Doctor Elrod, Decatur County; to Doctor Phinney, Randolph County; to Mr. McCaslin, Jay County; and to the geologist in chief, Jasper County.

In 1883 Professor Collett spent a part of the summer in Posey County, Doctor Brown being assigned to work in Morgan County, Doctor Elrod in Rush County, Doctor Phinney in Grant County, and Mr. McCaslin in Johnson County. Special assistants in 1883 were John M. Coulter, botanist; John N. Hurty, chemist; Fred. M. Stein, conchologist; Ralph S. Perry, entomologist; Fletcher M. Noe, ornithologist and taxidermist; Oliver P. Hay, herpetologist; and James Hall, C. A. White, and Leo Lesquereux, paleontologists. Lesquereux, as paleobotanist, presented in that year an elaborate description of the fossil botany of the Indiana coal fields.

During 1884 the department was left without funds through the failure of the legislature to pass the necessary appropriation bill. Doctor Collett, however, unwilling that the work should be suspended, proposed to pay the current expenses of the assistants from his private funds; $1,494.76 was thus advanced by Doctor Collett, who was subsequently reimbursed, however. Under these conditions Doctor Brown surveyed the counties of Hamilton and Madison, and Doctor Elrod, those of Fayette and Union. Professors Cope and

Wortman, of Philadelphia, furnished an elaborate paper on the Post-Pliocene vertebrates of Indiana, and Dr. J. S. Newberry one on the Drift deposits of Indiana.

The office of Professor Collett as geologist in chief expired in April, 1885, and Governor Gray appointed J. Maurice Thompson his successor, under whom Doctor Phinney was assigned to work in Henry County; Doctor Brown in Hancock; Prof. S. S. Gorby in Benton and Tippecanoe; and W. H. Thompson in Starke and Clinton counties.

Professor Thompson resigned in December, 1888, and was succeeded by S. S. Gorby, who, with W. H. Thompson and Charles R. Dryer, had been one of his assistants. S. A. Miller, it should be noted, served as paleontologist. In the sixteenth annual report it is said by Professor Gorby that no assistance had been allowed either in the museum or the field since his appointment. In the seventeenth annual report, bearing date of 1891, the following is given, showing the personnel of the survey: S. S. Gorby, State geologist; Maurice Thompson, assistant geologist; Moses N. Elrod, assistant geologist; Charles R. Dryer, chemist and geologist; S. A. Miller, paleontologist; O. P. Hay, herpetologist; W. S. Blatchley, entomologist; E. Bradner, botanist; J. E. Beasley, taxidermist; Thomas McQuade, inspector of mines; N. J. Hyde, supervisor of oils; E. T. J. Jordan, supervisor of natural gas.

In the eighteenth annual report (for 1893) the personnel is given as: S. S. Gorby, State geologist; Charles R. Dryer, assistant geologist; E. P. Cubberly, assistant geologist; S. A. Miller, paleontologist; J. N. Hurty, chemist; J. D. Kramer, chemist; W. B. Van Gorden, botanist; J. E. Beasley, taxidermist; Thomas McQuade, superintendent of mines; N. J. Hyde, supervisor of oils; E. T. J. Jordan, supervisor of gas.

In 1894 is was as follows: S. S. Gorby, State geologist; Thomas Elrod, assistant geologist; A. C. Benedict, assistant geologist; O. P. Hay, icthyologist.

In 1895 W. S. Blatchley was made State geologist. With him were associated T. C. Hopkins and E. M. Kindle, assistant geologists; W. A. Noyes and Robert Lyons, chemists; O. P. Hay, zoologist; Robert Fisher, inspector of mines; J. C. Leach, supervisor of natural gas; and C. F. Hall, supervisor of oil inspection.

In 1896 the personnel was still further increased. T. C. Hopkins and C. E. Siebenthal were employed in researches on building stone; George H. Ashley on coal; J. T. Scovell and A. F. Foerste on local geology; W. A. Noyes as chemist; M. A. Howe, physicist; J. C. Leach, supervisor of gas inspection; C. F. Hall, of oil; Robert Fisher, inspector of mines; and James Epperson, assistant inspector.

In 1897 the assistants were J. H. Ashley, in charge of coal survey, with C. E. Siebenthal, J. T. Scovell, and E. M. Kindle, paleontological assistants. A. F. Foerste served as assistant in local geology; A. W. Butler, as ornithologist; W. A. Noyes, chemist; J. C. Leach, supervisor of natural gas; C. F. Hall, supervisor of oil inspection; Robert Fisher, inspector of mines; and James Epperson, assistant inspector.

In 1898 J. A. Price was added to the force of assistants on the coal survey.

In 1899 R. E. Call served as conchologist and Stanley Coulter as botanist; E. B. Williamson, entomologist; W. C. Zaring, supervisor of oil inspection; and Charles Long, assistant inspector of mines; with these substitutions the personnel of the survey remaining as before. In 1900 E. M. Kindle served as paleontologist.

Salaries.—The salary of the State geologist was at first placed at $2,000 a year, but the amount was afterwards changed to $1,800 a year. The compensation for field and laboratory work was by the piece, the remuneration being determined by the chief geologist. The amount, however, is stated to have been always low.

Museum.—The number of specimens belonging to the State at the time of the transfer of the State museum by the department of agriculture to the bureau of statistics and geology (1879) was 8,912. The cost ($500) of arranging and cataloguing was borne by the State board of agriculture. To this number were then added by the bureau 11,649 pieces, of which 10,268 were acquired by purchase.

At the present time fossil flora of the early Carboniferous formations in the State are especially well represented. There is also a large and varied collection of stone implements and pottery of prehistoric age. A library, consisting chiefly of the reports of other surveys received in exchange, was built up.

Expenses.—The approximate total expense of the surveys succeeding Owen's is as follows:

Under E. T. Cox, 1869 to 1878, inclusive	$66, 000
Under John Collett, 1880 to 1884, inclusive	25, 000
Under Maurice Thompson, 1885 to 1887, inclusive	10, 000
Under S. S. Gorby, 1888 to 1894, inclusive	42, 000
Under W. S. Blatchley, 1895 to 1900, inclusive	38, 800
	$181, 800

During the year 1879–80 the sum of $505 was expended under Professor Collett's administration for geological purposes, as already noted.

The cost of printing and engraving the reports was borne independently of the geological appropriations.

CHARLES ABIATHER WHITE, RUSH EMORY, AND ORESTES ST. JOHN, 1866-70

SAMUEL CALVIN, 1892 1911

STATE GEOLOGISTS OF IOWA.

Publications.—An edition of 5,000 copies of each report was printed up to 1885, when the number was increased to 8,000 copies. But 5,000 copies were issued of the report for 1895.

Up to the year 1900, 25 volumes had been issued, ranging from 250 to 1,740 pages each, exclusive of maps. These reports were not sold, but were distributed in various ways. Some were given in exchange for other reports; others presented to literary and scientific institutions; to geologists engaged in scientific research; and the remainder to the several counties through the county auditors and county superintendents of schools.

IOWA.

FIRST GEOLOGICAL SURVEY UNDER JAMES HALL, 1855–1857.

A portion of Iowa was included in surveys made by David Dale Owen under authority of the United States General Land Office, in 1839. The first survey under State auspices was that made by James Hall and J. D. Whitney by virtue of the following enactment, approved January 23, 1855:

SECTION 1. *Be it enacted by the General Assembly of the State of Iowa,* That the governor may appoint, by and with the advice and consent of the senate, a State geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy, who shall hold his office for the term of two years unless sooner removed by the governor.

2. The said State geologist shall, by and with the consent of the governor, appoint one suitable person to assist him in the discharge of his duties, who shall be a skillful analytical and experimental chemist.

3. It shall be the duty of said geologist and his assistant, as soon as may be practicable after the appointment, to commence and carry on, with as much expedition as possible, a thorough geological and mineralogical survey of the State, as also of the character and quality of the soil for agricultural purposes.

4. It shall be the duty of the assistant to make full and complete examinations and assays of all rocks, ores, soils, and other substances which may be submitted to him by the State geologist for the purpose, and to furnish him with a detailed and complete account of results so obtained.

5. It shall be the duty of the State geologist, on or before the first Monday of December in each year, during the time not necessarily occupied by said survey, to make report of said survey and the progress thereof, accompanied with such maps, drawings, and specifications as may be necessary and proper to exemplify the same to the governor, who shall lay a copy of the reports before the general assembly.

6. It shall also be the duty of such geologist to forward to the governor, from time to time during the progress of said survey, such specimens of rocks, ores, coals, soils, fossils, and other mineral substances discovered and examined properly labeled, as may be proper and necessary to form a complete cabinet of collections of specimens of geology and mineralogy of the State; and the governor shall cause the same to be preserved for the benefit of the State, for public inspection. Said geologist shall cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the dif-

ferent geological formations of the State, and mark thereon the localities of the respective beds of deposits of the various mineral substances discovered, and the character of the soil; and, on the completion of the survey, to compile a memoir of the geology and mineralogy of the State, comprising complete accounts of the leading subjects and discoveries which have been embraced in the survey.

7. For the purpose of carrying into effect the provisions of this act the sum of $2,500 is hereby annually appropriated for the said term of two years, to be expended under the direction of the governor. The salaries of the geologist and assistant shall be fixed by the census board of the State; the salaries of the geologist and assistant, however, shall not commence until they have respectively entered upon the discharge of their duties; and upon the completion of said survey and the duties connected therewith the same shall cease and determine.

8. This act shall take effect and be in force from and after its publication in the *Iowa Republican* and *Iowa Capital Reporter.*

Early in 1857 an additional act was passed, as below:

An act making provision for the continuation of the geological survey of the State.

SECTION 1. *Be it enacted by the General Assembly of the State of Iowa,* That there be, and is hereby, appropriated from the treasury of the State, out of any moneys not otherwise appropriated, the sum of $10,000, to aid in the further prosecution of the geological survey of the State and to be expended under the direction of the governor.

SEC. 2. All geological specimens and fossils collected during said survey are hereby granted to the State University, and shall be deposited and carefully kept in a cabinet to be by that institution devoted to this purpose.

SEC. 3. This act shall take effect and be in force from and after its publication in the *Iowa City Republican* and the *Iowa Capital Reporter.*

Administration.—Under these acts Dr. James Hall of New York was appointed State geologist and J. D. Whitney, chemist and mineralogist. A. H. Worthen, subsequently State geologist of Illinois, was made assistant geologist. B. J. Hall and E. Hungerford also served, first as volunteer and afterwards as paid assistants. Mr. A. E. Cooley joined the force in the summer of 1857. Hall, in a personal report to Governor Grimes, thus outlined his results and views at the end of the first season's work:

ALBANY, *January, 1856.*

To His Excellency JAMES W. GRIMES, *Governor.*

SIR: In accordance with your instructions I proceeded to Iowa in September last to commence a geological survey of the State.

From my previous knowledge of the general geological structure of the State of Iowa, I was aware that an examination along the course of the Mississippi River would give me a complete section of the rock strata in the order of succession from the lowest to the highest or from the oldest to the newest formation as far as the Coal Measures. Accordingly, I proceeded at once to the north line of the State, making a cursory examination of the formations still farther north, which will enable me to show the connection of the geology of Iowa with that of Minnesota.

With the exception of several excursions into the interior in order to trace out more fully some of the formations, my whole time was expended in the investigations along the Mississippi River. I have examined with care all the exposures of rock from the northern line of the State to the mouth of the Des Moines River, and I have the materials for constructing a well-defined section of the rocks along this whole line. This section will be the groundwork for all future operations in the interior of the State and is very important as preliminary progress in the survey. The limits of each formation along the river line are now well ascertained, as also the character and order of succession among the different beds, giving us greater facility and certainty in tracing the continuation of the same formations into the interior of the State when the great accumulation of drft material often obscures the underlying rocky strata.

During this investigation I have been able to prove the existence of several rock formations not before known in the State, though well known in New York and elsewhere. The facts thus ascertained will show that the geological series in Iowa is much more complete than had heretofore been supposed, and it places us at once in the position to make comparisons between its geology and the geology of other portions of our country which have been accurately studied.

The lowest rock which I find in Iowa on the Mississippi River is that known as the Potsdam sandstone, being the lowest fossil-bearing rock in the known world. This rock with all those above it dips beneath the level of the river as we descend the stream, admitting an examination of all the beds in succession as they descend to the river level.

The formations thus recognized in their ascending order are the Potsdam sandstone, Calciferous sandstone (lower magnesian limestone of Owen); the sandstone of the Chazy period; the Birdseye, Black River, and Newton limestones; the Galena limestone; Hudson River group; Niagara limestone; a group of limestone beds above the Niagara limestone requiring a new designation. The Onondaga salt group; the lower Helderberg limestones; the Hamilton group; the Chemung group; the Burlington limestone; the cherry beds of the Lower Rapids; the Keokuk and Warsaw limestones. The latter are succeeded by the Coal Measures of Iowa, which occupy much of the southern and central portions of the State.

The small area of coal measures which begins above Davenport and extends to below Muscatine along the river is but a narrow and interrupted belt, and has no connection with the series of coal measures which occupy the interior of the State.

The Burlington and Keokuk limestones belong to the series termed "Carboniferous limestones," as well as some succeeding beds not seen at Keokuk.

As there existed much confusion in regard to the Carboniferous limestones, as elucidated in the report of this part of the country, I found it necessary to trace these formations some distance south of the limit of Iowa, when they become more fully developed and the facilities for studying their relations are more favorable. Consequently, after the season had so far advanced that I could no longer work in the State I carried forward my investigations to the southward, with the most gratifying results. These results I shall give in detail in the report hereafter to be made, and I flatter myself that it may not be without interest to the people of Iowa, as I feel sure that it will be regarded as of the greatest interest to the science of geology.

Mr. Whitney has devoted his time mostly to the lead region in the vicinity of Dubuque and will be prepared to communicate next year some valuable information. He has also examined the iron ore of the Maquoqueta Valley, and we shall be prepared to speak fully in reference to its extent and value.

From what has been done already I feel that the geology of Iowa will have a great interest when once thoroughly worked out and the results presented to the public. In regard to the scientific results, or those which will attract attention in the scientific world, I feel that there is already more material than I had expected the entire survey to yield.

Publications of the survey.—The manuscript of the final report would appear to have been submitted early in 1857 or the latter part of 1856. Its receipt gave rise to the following joint resolution providing for the distribution of the reports:

Resolved by the General Assembly of the State of Iowa, That the governor be, and is hereby, authorized to procure the printing of 2,000 copies of the report of the State geologist, and that he cause one copy thereof to be transmitted to each member of the general assembly and the remainder to be deposited in the office of the secretary of state.

Resolved, That the governor be further authorized to draw his warrant on the State auditor for the expense thereof, who shall audit and allow the same.

For reasons beyond the control of the authors, due mainly, as it appears from the report, to delay in engraving the necessary plates, the volume was not ready for the printer until September, 1858, when it was issued in two parts, the first being given up mainly to general geology and physical geology and the second to paleontology. The survey was discontinued at the end of the two years set by the law of establishment. Hall, however, with characteristic persistence, refused to give up, and in 1860 wrote the Hon. W. H. F. Gurley suggestions for its revival, as follows:

To the Hon. W. H. F. Gurley,
Chairman of the Committee of Ways and Means
of the House of Representatives of Iowa, 1860.

Sir: I take the liberty of submitting for your consideration some suggestions regarding the geological survey and its continuation, which are essentially the same as I have already verbally communicated to the committee of the two houses.

There are two ways in which the geological survey may be continued for the next two years without making the larger appropriation that would be required to complete the survey of the western half of the State.

One of these modes will be the one already proposed to the committees, which requires that I shall keep one assistant in the field, whose especial duty it shall be, under the direction and supervision of the State geologist, to make careful exploration of the counties occupied by the coal measures, and the results to be laid down on the county maps in the same manner as upon those maps already shown to the committee; and beyond this to provide for the completion of certain laboratory and office work which has been already commenced, and which is necessary in the preparation of the materials previously collected and those to be collected, for another report of the character of that already made. It is absolutely necessary that this latter work shall go on or much will be lost that is already practically completed, and it will cost much more in the end should it now be dropped and taken up again after two years or at any future time.

By this means the localities and position of the coal beds, their extent and thickness will be determined, and the resources of the State in this important mineral will be thoroughly developed. It is unnecessary to enlarge upon the importance to the State of a thorough knowledge of the extent and character of the coal formation in the western and southwestern parts of the State.

It should be provided also that there be authority to publish such results of this survey as shall be deemed important for giving information to the people in regard to this and other mineral resources of the State, or any other facts of interest and importance which may be made known in connection with the survey.

It is very desirable also that certain investigations be made in the lead region of Dubuque, with a view to the completion of the map of that region, and which shall conform in perfection with the maps of the adjacent portions of Wisconsin and Illinois, including the entire lead region of the Northwest.

To accomplish this will require $2,000 annually for actual expenditures, without providing anything as salary for the State geologist.

Should the committee prefer to consider the question of completing the work in the lead region and the publication of the map as proposed, I submit the following memoranda regarding an equitable division of the necessary expenditure.

The great lead region of the Northwest lies in the States of Wisconsin, Iowa, and Illinois, much the greater part of it being within the State of Wisconsin, and the finishing of the map will be completed during the present year. As these States are individually and mutually interested in this mineral region and all that pertains to it, it is proposed that each contribute to the expense of the publication, so that the map may be presented as a whole, and the report embrace the consideration of the entire region, by which means the inhabitants of each State could possess the complete work.

I give below the estimated cost of printing geological report of the lead region:

Cost of engraving and printing geological map, number of copies 2,500	$1,500
Same number of large crevice map	750
Cost of printing report with the necessary illustrations	1,500
	$3.750

This expense to be divided as follows. Wisconsin, three-fifths, $2,250, number of copies, 1,500; Iowa, one-fifth, $750, number of copies, 500; Illinois, one-fifth, $750, number of copies, 500. These sums are exclusive of field work.

Should this plan be adopted and a larger number of copies were required by Iowa—a number corresponding to that of the geological report already printed—that number could be had for the additional cost of paper and printing, the original cost of the engraving and the composition of the letterpress having been defrayed at the joint expense of the States interested as above indicated.

This report on the entire lead region could, moreover, be incorporated in a volume with other results of the Iowa geological survey, the paging being so arranged as to admit of the other matter following in its proper order.

If the 500 copies alone were sufficient these may be secured for the sum of $750 as above, with the addition of $500 for the completion of the field work. The field work in the lead region of Wisconsin will be completed this year, and the map will be completed this year, and the map will be ready for the engraver as early as November next. The geological map mentioned embraces the entire lead region of the three States, and is about 30 by 40 inches. The crevice map shows all the known workings of Iowa and Illnois, and the most important part of those in Wisconsin, laid down on a large scale in red lines, on a map about 3 by 5½ feet. It is probable and indeed almost certain that the Legislature of Wisconsin will order the engraving of one or both these maps the present year, and should the Legislature of Iowa take no action in regard to the matter, I propose to take some step by which the use of the engraving can be secured to Iowa at some future time.

In accordance with the plan of the survey indicated above, every one of the 300 copies of the Iowa geological report sent to foreign governments and societies, as well as to the State governments, is accompanied by a circular stating that the work of the survey is in progress and that a second volume will soon be published, and that the State is desirous of securing European works from their public libraries in exchange.

I might here state that the ultimate plan of the survey contemplates a complete exploration of the western half of the State, with carefully examined sections of the valley of the Des Moines and of the Missouri, which will be engraved in a similar manner to that given of the Mississippi Valley in the first volume. Examinations of the drift and alluvial materials of the surface and the soils have been commenced and a large accumulation of facts relative to the soils of the eastern half of the State collected. The discussion of this subject in all its bearings can not be properly taken up until the western half of the State shall have been examined, when this department of the survey will receive that attention which its importance demands.

In making the preceding statement I have borne these facts in mind, and aware of the necessity of economy, I have asked for the smallest sum that will enable me to do the work proposed and to preserve the materials collected and prepare them for a future report, and at the same time secure that priority for the State of Iowa to which she is entitled by the publication, at a trifling expense of such matters as might otherwise be lost to us; and by this means secure originality or the result of original investigation for the future complete report, the character of which I am very desirous should be kept up to the standard of the preceding volumes.

* * * * * * *

(Signed) JAMES HALL.

Nothing seems, however, to have come from this, but as late as 1865 Hall wrote Governor Grimes:

I never understood that I was appointed by you for any specific time, but to complete the survey, and your instructions to me were that I should make volume 1 of such a character that another volume of similar size would contain the entire result. This plan was adopted, and I felt that should there be a disposition to resume the survey an opportunity would be given me to make another volume as promised.[1]

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[1] It appears further from correspondence that Hall was never fully reimbursed for certain outlays which he had felt justified in making, though sundry appeals were made to the legislature to remedy the omission. In one instance a member made a distinct offer to get a bill through, or, if unsuccessful in his attempt, to procure the passage of an act that would enable Hall to sue for it in the county courts; this, however, on the following extraordinary terms: "Namely, for one-half (the amount) if successful, or nothing if not." The undertaking was deservedly unsuccessful, the member writing under date of May 27, 1872: "I am sincerely ashamed of the conduct of the State in ignoring your claim under the circumstances and done (sic) my very best to wipe out the stain."

Expenses.—The total expense would appear from the appropriations to have been $5,000 for salaries and $10,000 for publication, a total of $15,000.

SECOND GEOLOGICAL SURVEY UNDER CHARLES A. WHITE, 1866–1870.

With the discontinuance of the Hall-Whitney survey, matters in Iowa lay dormant until 1866, when a movement for its completion culminated in the following enactments:

An act providing for the completion of the geological survey of the State of Iowa.

SECTION 1. *Be it enacted by the General Assembly of the State of Iowa*, That for the purpose of completing the geological survey of the State, Charles A. White, of Johnson County, is hereby appointed State geologist and shall hold his office for the term of two years or until his successor is appointed.[1]

SEC. 2. The State geologist shall be authorized to appoint a competent assistant, and also a skillful analytical and experimental chemist, who shall report to the State geologist the analysis of such soils, rocks, coals, ores, and other mineral substances as he may submit to him for that purpose. He shall also have power to employ such further assistance as he may deem necessary to prosecute promptly and efficiently the field work connected with the survey. All persons employed by him shall be under his direction and subject to removal by him. All the specimens of minerals, fossils, rocks, soils, coals, ores, or other geological or mineral substances of any value or interest to either the practical or amateur geologist, and any drawings or sketches of the same obtained or made by the State geologist, as well as the copyright of the reports, and all books printed therefrom shall belong to the State, and no specimens, copy, draft, or part of the same shall be given away or sold, or be permitted to be carried away contrary to the provisions of this act. And the State geologist or any of his assistants or employees or any person who shall violate any provision of this section shall be deemed guilty of a misdemeanor.

SEC. 3. It shall be the duty of the State geologist and his assistants to carry on with as much expedition as practicable the geological and mineralogical survey of the State, including observations and examinations of the soil for agricultural purposes. He may also include in his report such matters as pertain to physical geography and such other matters as properly and usually pertain to a survey of this kind, it being expressly required of the State geologist and his assistant that these duties be performed in such a manner as to give to the people of the State the greatest amount of practical information in relation to its resources.

SEC. 4. It shall be the duty of the State geologist on or before the first Monday of January of each year to prepare a report of said survey and its progress, accompanied by such maps and drawings as may be necessary to illustrate the same, and transmit them to the governor, who shall lay a copy of such reports before the general assembly. The State geologist shall, as far as practicable, use such words in his reports as are in common use, and that he shall accompany each volume of his reports with a glossary. It shall also be his duty to prepare, from time to time during the progress of the survey, communications for publication in the newspapers of the State, provided it shall be done without expense to the State, embodying such information in reference to the character and quality of the soil, deposits of coal, minerals, and other valuable substances as he may deem of general interest and importance to the public.

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[1] It appears from correspondence that Professor Hall still considered himself as entitled to the appointment, and was inclined to resent Doctor White's candidacy. He, however, declined to accept the directorship excepting under "practically the same basis as the old."

SEC. 5. It shall be the duty of the State geologist to cause collections to be made of rocks, soils, fossils, coals, ores, and other mineral substances discovered or examined, which shall be disposed of as follows, to wit, all rare specimens of which duplicates can not be found, and all specimens from which descriptions or illustrations are drawn for publication, shall be deposited in the cabinet of the State University. A full series of the best of such specimens as more particularly exemplifiy the economic geology of the State shall be deposited in the cabinet of the State agricultural college. All other specimens shall be distributed to the cabinets of all other organized institutions of learning in the State, giving preference to the State University, the State agricultural college, and the medical college at Keokuk.

SEC. 6. For the purpose of carrying out the provisions of this act the sum of $6,500 is hereby annually appropriated for the term of two years out of such moneys in the treasury as are not otherwise appropriated. This fund shall be drawn from time to time for the purposes of the survey on requisitions signed by the State geologist and approved by the census board. The salary of the State geologist shall be $2,000 annually, and the salary of his assistant shall be fixed by the State geologist in such amounts, not exceeding $1,500 annually, and for such periods as he may deem proper, but which shall not exceed the term of his own appointment. The rate of pay of all other persons employed by the State geologist shall be fixed by him, but shall not exceed the usual price paid for the kind of labor performed, nor in any case shall it exceed $4 per day.

SEC. 7. All acts and parts of acts in contravention of the provisions of this act are hereby repealed, and all appointments made under the provisions of said acts are hereby annulled.

SEC. 8. This act shall take effect and be in force from and after its publication in the *Iowa State Register* and *Iowa Homestead*, newspapers published at Des Moines.

Under this act work was immediately begun, and at the close of 1867 a preliminary report was made, which was published in pamphlet form. The continuation and completion of the work was provided for by the following act:

An act providing for the further prosecution and completion of the geological survey of the State.

SECTION 1. *Be it enacted by the General Assembly of the State of Iowa*, That for the purpose of the completion of the geological survey of the State that the present State geologist be continued in office, and that the sum of $6,500 be hereby annually appropriated, out of such moneys in the State treasury as are not otherwise appropriated, until the said survey is completed, or until the general assembly shall order its discontinuance. This appropriation shall be drawn from time to time for the purposes of the survey and the payment of the salaries of its officers as defined and limited in chapter 73 of the acts of the eleventh general assembly, upon requisitions signed by the State geologist and vouchers approved by the census board and filed with the auditor of State.

SEC. 2. The State geologist is hereby required to complete the geological survey of the State on or before the 1st day of January, 1870, and to prepare a full and complete report of said survey, accompanied by such maps and drawings as may be necessary to illustrate the same, and transmit them to the governor, who shall lay a copy of such reports before the general assembly.

SEC. 3. On or before the first Monday in each year the State geologist shall prepare careful statements of his accounts with the survey for the previous year, embodying them in the form of a financial report, and send the same to the governor, together with such vouchers as it may be practicable for him to obtain; and the governor shall lay the whole before the general assembly, together with the report of progress of the State geologist.

SEC. 4. All acts and parts of acts in contravention of the provisions of this act are hereby repealed.

SEC. 5. This act shall take effect and be in force from and after its publication in the *State Register* and *Evening Statesman.*

Approved April 8, 1868.

I hereby certify that the foregoing act was published in the *Iowa Evening Statesman*, April 17, 1868, and in the daily *State Register*, April 19, 1868.

ED. WRIGHT, *Secretary of State.*

The thirteenth general assembly failed to make any provision for the continuation of the work, but passed the following law providing for the publication and distribution of the report:

An act providing for the publication of the report of the State geologist and for the distribution of the same.

SECTION 1. *Be it enacted by the General Assembly of the State of Iowa,* That the census board be and are hereby authorized to contract with the present State printer for 3,000 copies of the report of the State geologist as now presented to this general assembly: *Provided*, the expense shall not exceed $10 per copy for the first 1,000 copies, and $4 per copy for each additional copy. Said report to be equal in every respect, mechanically, to Hall's Geological Report of Iowa, or to the Illinois geological reports; the engravings, views, maps, diagrams, etc., to be equally as well executed; and the whole to be bound in two royal octavo volumes: *Provided, further*, that the said State printer shall, in consideration of the copyright of the report, stereotype the work and retain the plates and the engraved stones and electrotypes, and supply the State on future orders at $5 per copy.

SEC. 2. The State geologist shall superintend the publication of said report and be allowed a reasonable compensation therefor, to be fixed by the census board, and paid out of the fund heretofore appropriated for the prosecution of the geological survey and remaining unexpended.

SEC. 3. That for the purpose of carrying out the provisions of section 1 of this act there is hereby appropriated out of any moneys in the State treasury not otherwise appropriated the sum of $18,000, or so much thereof as may be necessary.

SEC. 4. That the report, when printed and bound, shall be disposed of as follows—to wit: Two copies to every member of the thirteenth general assembly, every officer of State, and each judge of the supreme court; one copy to each person who was a member of the eleventh and twelfth general assemblies, to each officer of the senate and house, and each regular reporter of the thirteenth general assembly, to the office of each county auditor in the State, to each incorporated college and scientific institution in the State, to each orphans' home and reform school, and to each person who has furnished gratuitous material for publication in the report; 25 copies to the State university, the State agricultural college, the State geologist, and the State library; five copies to the assistant and chemist of the survey; two copies each to the institutions for the deaf and dumb, and blind, and both hospitals for the insane; 100 copies to be placed in the hands of the governor and State geologist for distribution to scientific men and learned societies and colleges beyond the limits of the State; the remaining copies to be placed in the hands of the secretary of state and disposed of as the census board may direct.

Sec. 5. That all acts or parts of acts in contravention of the provisions of this act are hereby repealed.

Sec. 6. This act shall take effect and be in force from and after its publication in the *Daily Iowa State Register* and the *Daily Evening Statesman*, newspapers published at Des Moines, Iowa.

Approved April 13, 1870.

Personnel.—The personnel of the survey was limited to Dr. C. A. White, State geologist; Orestes St. John, assistant geologist; and Rush Emery, chemist. The appointment of assistants was by law in the hands of the director of the survey. The salary of the State geologist was fixed by the law of March 30, 1866, at $2,000 a year, and that of the assistants at amounts not exceeding $1,500 a year.

Museum and library.—The law of establishment required that all specimens, drawings, sketches, books, etc., obtained or made by the State geologist, should become the property of the State.

Expenses.—The total expense of the White survey, as indicated by the appropriations, was as follows: For 1866 to 1868, $13,000;[1] for 1868 to 1870, $13,000(?); for publications, $18,000.

Publications.—Two reports of progress, under date of 1868, were issued, and a two-volume final report of viii+380 and viii+443 pages, under date of 1870, the edition authorized by the law of April 3, 1870, being limited to 3,000 copies, at a cost, as above noted, not exceeding $1,800. The distribution of the volumes was also controlled by the same law, to which reference may be made.[2]

THIRD GEOLOGICAL SURVEY UNDER SAMUEL CALVIN, 1892–1900.

With the close of the White survey in 1870, geological work at the expense of the State was discontinued until 1892, when it was again taken up under authority of the following act:

An act to provide for a geological survey of the State of Iowa.

Be it enacted by the General Assembly of the State of Iowa:

Section 1. There is hereby created and established a geological survey for the State of Iowa, which shall be under the direction and in charge of the geological board, which shall consist of the governor, the State auditor, the presidents of the agricultural college and the State university, and the Iowa Academy of Sciences.

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[1] Doctor White informed the writer that some $2,000 of this first appropriation was unexpended and returned to the Treasury.

[2] The first annual report consisted of but three pages, and a "few" copies only issued. The matter was, however, reprinted with the second annual, together with a number of letters written by Doctor White for the newspapers and while in the field.

SEC. 2. The duties of the geological board shall be to have oversight and full control of the surveys, except as herein otherwise provided; to appoint a State geologist and such expert assistants, recommended by the State geologist, as may be necessary to audit accounts; and to annually furnish for publication a report of the operations of the survey.

SEC. 3. The duty of the director or State geologist shall be to make a complete survey of the natural resources of the State in all their economic and scientific aspects, including the determination of the order, arrangement, dip, and comparative magnitude of the various formations; the discovery and examination of all useful deposits, their richness in mineral contents, and their fossils; and the investigation of the position, formation, and arrangement of the many different ores, coals, clays, building stones, glass sands, marls, peats, mineral oils, natural gas, mineral and artesian waters, and such other mineral materials as may be useful, with particular regard to the value of said substances for commercial purposes and their accessibilities; also the quasi noting of the characters of the various soils and their capacities for agricultural purposes; the growth of timber and other scientific or natural history matters that may be of practical importance and interest. A complete cabinet collection may, at the option of the board, be made to illustrate the natural products of the State; and the board may also furnish suites of materials, rocks, and fossils for colleges and public museums located within the State, provided the general State collection is not made to suffer thereby.

SEC. 4. It shall, further, be the duty of the State geologist to make, or cause to be made, detailed maps and reports of the counties or districts as fast as the work is completed, which maps shall embrace all such geological, mineralogical, topographical, and scientific details necessary to make complete reports of the said districts. Whenever the information obtained warrants it the results of any special investigation of agricultural or geological phenomena shall be brought together in a memoir of final report for publication, accompanied by proper illustrations and diagrams. On or before the first day of January of each year the State geologist shall lay before the geological board a full report of the work of the preceding year, together with such minor reports and papers as may be considered desirable for publication. When occasion requires important information may be issued in the form of special bulletins for the immediate use of the people at large. From time to time items of general interest or announcements of new discoveries may be furnished the newspapers or periodicals for publication.

SEC. 5. The reports contemplated in this act shall. under the direction of the board, be disposed of as follows: 1. To each of the present State officers and to each member of this assembly who shall annually send his address to the geological board, one copy of each published volume; and to each member of any future assembly which shall authorize the publication of any report, one copy of such report shall be sent. 2. Twenty copies of each volume published shall be furnished to the State library; 10 copies to the State historical society, State university, State agricultural society, and State horticultural board; two copies to each chartered college and normal school in Iowa; and to the libraries of each State institution, the Iowa academy of sciences, Davenport academy of sciences, and to the general officers of each railroad that has furnished aid to the survey. 3. One copy of each volume to each public library; to the library of each academy or other educational institution; to each scientific society in the State; to each first-class library; to each scientific survey or organization issuing regular publications, beyond the limits of the State; and to each geologist of national reputation on receiving his written application therefor. 4. All remaining volumes, after retaining a sufficient number to supply future demands, shall be sold to persons making application for them at the cost price of publication of such volume, the moneys thus accruing to be turned into the treasury of the State.

SEC. 6. For the purpose of carrying out the provisions of this act the sum of $10,000, or as much thereof as may be needed, is hereby annually appropriated for the next biennial term.

SEC. 7. The members of the board shall be allowed the actual expenses attending the duties assigned them by this act. The salary of the State geologist and his expert and all other assistants shall be fixed by the geological board, and shall be a part of and come out of the sum provided for in section 6. The necessary postage, stationery, and office expenses of the State geologist shall be paid by the State as the expenses of other State officers are provided for. The expense of printing, engraving, binding, and distribution of the reports of the survey shall be paid out of any moneys, not otherwise appropriated, in the State treasury on warrants of the State auditor approved by the geological board.

SEC. 8. All previous acts or parts of acts inconsistent with this act are hereby repealed.

Administration.—Under this act Prof. Samuel Calvin was appointed State geologist and served continuously until 1904. The personnel during the several years up to and including 1900 was as follows:

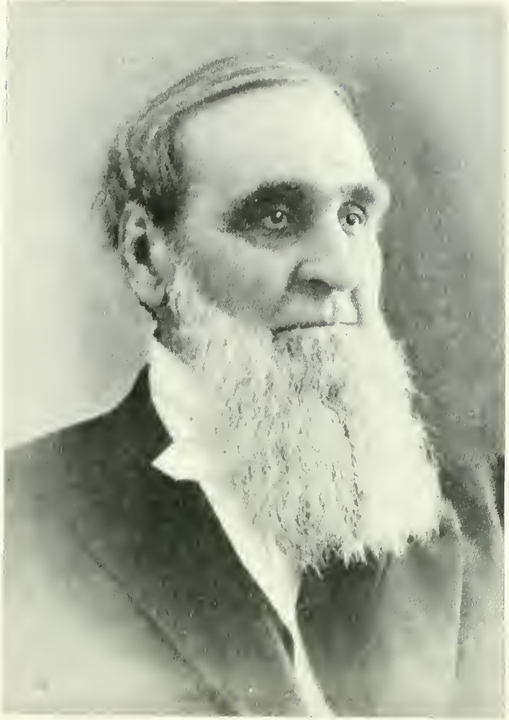
1892. Samuel Calvin, State geologist; Charles R. Keyes, assistant State geologist; S. W. Beyer, G. L. Houser, C. D. Jameson.

1893. Geological corps: Samuel Calvin, State geologist; Charles R. Keyes, assistant State geologist; G. E. Patrick, chemist. Special and temporary assistants: S. W. Beyer, H. F. Bain, N. E. Newman, E. H. Lonsdale, A. C. Spencer, A. G. Leonard, F. C. Tate, C. D. Jameson, A. J. Jones, W. H. Norton, J. L. Tilton, F. M. Fultz, C. H. Gordon, and J. P. Farnsworth.

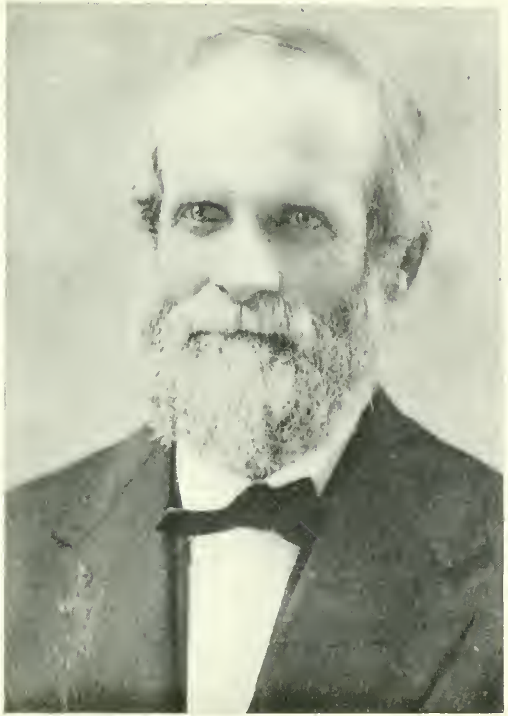
1894. Geological corps: Samuel Calvin, State geologist; Charles R. Keyes, assistant State geologist; G. E. Patrick, chemist; special assistants, S. W. Beyer, H. F. Bain, N. E. Newman, E. H. Lonsdale, A. C. Spencer, A. G. Leonard, F. C. Tate, A. J. Jones, W. H. Norton, J. L. Tilton, F. M. Fultz, C. H. Gordon, and A. G. Wilson.

1895. Geological corps: Samuel Calvin, State geologist; H. F. Bain, assistant geologist; special assistants, W. H. Norton, S. W. Beyer, A. G. Leonard, J. L. Tilton, N. E. Newman.

1896. Geological corps: Samuel Calvin, State geologist; H. F. Bain, assistant geologist; A. G. Leonard, assistant geologist; special assistants, W. H. Norton. S. W. Beyer, J. L. Tilton, N. E. Newman.



George Clinton Swallow, 1865-66



Benjamin Franklin Mudge, 1864

STATE GEOLOGISTS OF KANSAS.

1897. Geological corps: Samuel Calvin, State geologist; H. F. Bain, assistant geologist; special assistants, W. H. Norton, S. W. Beyer, J. L. Tilton, N. E. Newman.

1898. Geological corps: Samuel Calvin, State geologist; H. F. Bain, assistant geologist; special assistants, J. B. Weems (chemist), S. W. Beyer, W. H. Norton, J. A. Udden, N. E. Newman.

1899. Geological corps: Samuel Calvin, State geologist; H. F. Bain, assistant geologist; special assistants, J. B. Weems, S. W. Beyer, W. H. Norton, J. A. Udden, T. H. Macbride, F. A. Wilder, B. L. Miller, T. J. Savage, I. A. Williams, N. E. Newman.

1900. Geological corps: Samuel Calvin, State geologist; A. G. Leonard, assistant geologist; special assistants, J. B. Weems, S. W. Beyer, W. H. Norton, J. A. Udden, T. H. Macbride, F. A. Wilder, B. L. Miller, T. J. Savage, I. A. Williams, N. E. Newman.

As the law provided, the survey was under direction of a board, which appointed the State geologist and such expert assistants as he might recommend.

Salaries and expenses.—The salary of the geologist, who is also professor of geology in the State university, is $800; that of the assistant geologist, $1,500. The appropriation for 1892 was $10,000 and for 1893 to 1900, $5,000 annually; a total of $50,000.

Publications.—Eleven volumes of reports were issued, beginning with 1892, up to 1900. The size of the editions was 3,000 volumes, of which 2,000 volumes were bound in cloth and 1,000 volumes in paper. The cost of these issues was as follows: Volume I, Annual Report for 1892, $2,600; Volume II, Special Report on Coal, and Volume III, Annual Report for 1893, $5,800; Volume IV, Annual Report for 1894, $3,600; Volume V, Annual Report for 1895, and Volume VI, Special Report on Artesian Wells, $5,250; Volume VII, Annual Report for 1896, $3,750: Volume VIII, Annual Report for 1897, $3,750; Volume IX, Annual Report for 1898, $4,200; Volume X, Annual Report for 1899, $5,400; Volume XI, Annual Report for 1900, $4,200.

KANSAS.

FIRST SURVEY UNDER BENJAMIN F. MUDGE, 1864–1865.

Prior to 1864 the little that was known of the geology of Kansas was due to the disconnected and often hasty notes by members of various exploring expeditions, as those of Long, 1819–20, Fremont, 1842–1844, Stansbury, 1849, and Messrs. Swallow, Hawn, and F. B. Meek in 1858. In 1864 the matter of a systematic survey was taken up through the medium of the following act, the passage of which is said to have been instigated chiefly by Benjamin F. Mudge, who became the first State geologist:

An act providing for a geological and mineralogical survey.

Be it enacted by the Legislature of the State of Kansas:

SECTION 1. The governor is hereby authorized to appoint, with the consent of the senate, a State geologist for the State of Kansas, whose term of service shall commence on the first day of March, A. D. 1864, and end on the first day of March, A. D. 1865.

SEC. 2. The State geologist shall procure the necessary regents and all the requisite apparatus for quantitative and qualitative analysis. He shall procure the necessary assistance and proceed to classify the rocks and soils of each county of the State. He shall visit and analyze the salt springs already discovered, and use due diligence in efforts to discover others. He shall investigate coal formations and other mineral deposits by the various appliances known to the departments of geology and mineralogy. He shall analyze the soils in the several settled counties, report their depth, and show their adaptation for the growing of particular grains and grasses. He shall immediately report any important discoveries of valuable deposits or other matters of great importance to the State. He shall, during the current year, collect and label a geological cabinet, illustrating the geology of Kansas, and shall deposit the same with the State librarian.

SEC. 3. He shall, between the first day of November and the first day of December, A. D. 1864, make and deliver to the governor his annual report, which shall contain a complete detail of his labors and discoveries during the year.

SEC. 4. The governor is hereby authorized to direct the auditor of the State to draw his orders on the State treasurer for such sums as, in his judgment, may be necessary for the successful prosecution of the survey, said sums not to exceed in the aggregate $3,500 during the year. These orders shall be marked "Geological survey": *Provided*, That no bills for services rendered, or expenses incurred by the State geologist, shall be paid until a detailed statement, specifying the number of days' service, and the items of expenses verified by affidavit, and approved by the governor and filed with the auditor of State.

SEC. 5. Before entering upon the duties of his office the State geologist shall enter into bond to the State of Kansas in the sum of $5,000, with security to the satisfaction of the governor of the State, conditioned that he will faithfully and properly perform the duties of his office, and he shall take and subscribe the following oath:

"I, ______, State geologist for the State of Kansas, do solemnly swear that I will support the Constitution of the United States and the constitution of the State of Kansas, and faithfully discharge the duties of my office as prescribed by law, according to the best of my ability."

SEC. 6. The governor shall have power to remove such appointee for incompetency or neglect of duty and to fill all vacancies that may occur by death or otherwise.

SEC. 7. This act shall be in force from and after its publication once in the *Topeka Tribune.*

Approved, February 10, 1864.

Administration and personnel.—Under this law Professor Mudge, as stated above, was appointed State geologist, with Maj. F. Hawn, a civil engineer, chief assistant; G. C. Swallow, paleontologist; Dr. Tiffin Sinks, chemist and mineralogist; and C. A. Logan, botanist. The work, as must be evident, was limited both in time and funds, and but little accomplished.

Results.—The report of his work, a pamphlet of but 56 pages, did not appear until 1866. The first 15 pages of this was given up to "General principles" and the remainder to "Economical geology."

In part first he recognized the following geological horizons, beginning with the oldest and lowermost: (1) Coal measures, (2) Permian, (3) Triassic, (4) Cretaceous, (5) Drift, (6) Loess, and (7) Alluvium. It would appear that the development within the State of either the Sub-Carboniferous or the Tertiary deposits was unrecognized. In the short notice given to the Cretaceous deposits which had received very little attention, there was foreshadowed the discovery that the Kansas Cretaceous system yields true chalk.

Considerable attention was given in this report to the items of coal and salt. In connection with the former he gave some account of the boring for coal which had then begun in Leavenworth County, and a geological section of the strata of Leavenworth County was given to a depth of 400 feet. This boring ultimately reached coal at a depth of over 700 feet. A full description of the Tuthill salt marsh in Republic County was given, and references made to other developments of salt brines in wells, streaks, and springs. Some of these were compared with the sources of salt utilized in New York and elsewhere, and analyses and methods of manufacture also given in detail.

Expenses.—The total expense of the year's work was apparently covered by the appropriation—$3,500.

SECOND SURVEY UNDER GEORGE C. SWALLOW, 1865–1866.

An act making an appropriation for a geological survey.

Be it enacted by the Legislature of the State of Kansas:

SECTION 1. The governor is hereby authorized to appoint, with the consent of the senate, a State geologist for the State of Kansas, whose term of service shall commence on the first day of March, 1865.

SEC. 2. That the sum of $7,500, or so much thereof as may be needed, is hereby appropriated out of any money in the State treasury not otherwise appropriated for the prosecution of the geological survey for the year 1865: *Provided*, That services rendered or expense incurred by the State geologist shall not be paid until a detailed statement, specifying the number of days' service and the items of expenses, verified by affidavit and approved by the governor, be filed with the auditor of state.

SEC. 3. The auditor of state shall issue his warrant on the treasurer of the state for such accounts as the governor shall approve.

SEC. 4. This act shall take effect and be in force from and after its publication once in the *Daily State Record*.

Approved February 11, 1865.

Administration and personnel.—Under this law G. C. Swallow, paleontologist for the first survey, became director. Otherwise the personnel remained as under Professor Mudge's administration.

Results.—In a single report, a pamphlet of 192 pages, issued in 1866, are given reports discussing the climate as relating to health and to various forms of disease, rainfall, and other meteorological phenomena. As the legislature had prescribed work to be done in each county, this volume had a special report on the geology of Miami County, giving a section of the formations found therein and investigating the questions of petroleum, iron, and coal. Major Hawn contributed reports on eight counties, though these were not nearly as full as that of Miami, which appears to have been very thoroughly examined as a typical region of the coal-measure epoch. Briefer reports were made of Brown, Doniphan, Chase, Lyon, Linn, Butler, Osage, and Morris counties. The Loess is recognized as occurring in Lyon, Chase, and Morris counties, and also is spoken of as occurring in the northwest corner of the State in the Republican Valley. The rocks of these three last-named counties are described as Permian. Reference is made to drawings of sections and lists of fossils, which were, however, never published, and no further appropriations were made for continuing the work. It is useless to discuss the reasons for this discontinuance, as the appropriation was stopped before the report was distributed. When it was finally issued the work was severely criticized by geologists of the East, and it would appear that it erred in making exact statements where only approximations were possible, and in attempting too much by rapid explorations in obedience to an unreasonable public demand for immediate results.

This survey died a natural death through the failure of the legislature to make the necessary appropriations. It is stated that at various times between 1866 and 1895 unsuccessful attempts were made to revive it, bills for that purpose being introduced at nearly every session of the legislature. It was not, however, until 1889 that anything definite was actually accomplished, when a law was passed under which the survey at present in progress was actually organized in 1895. (See Bull. 465, U. S. Geological Survey.)

Expenses.—The appropriations for the two surveys amounted to $11,000.

KENTUCKY.

FIRST GEOLOGICAL SURVEY UNDER THE DIRECTION OF DAVID DALE OWEN; 1854–1860.[1]

Preliminary remarks.—In Collins's Historical Sketches of Kentucky (vol. 1, p. 26), it is recorded that "lands were granted by the legislature, January 31st, 1811," at the nominal price of 10 cents an

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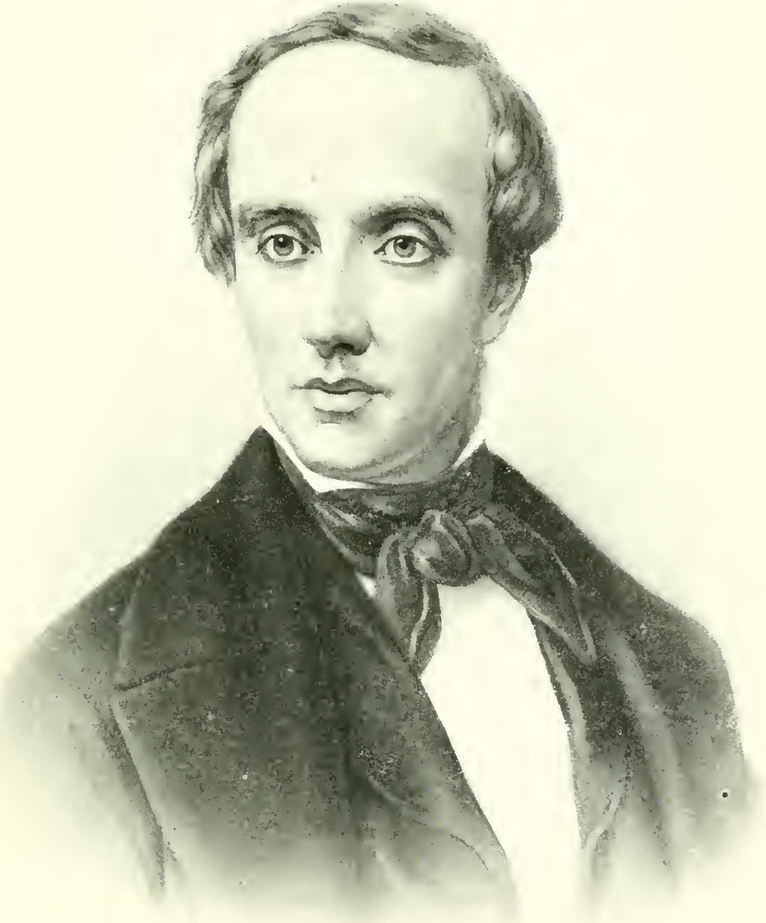
[1] From manuscript by Dr. Robert Peter, State chemist of Kentucky.



DAVID DALE OWEN

STATE GEOLOGIST OF KENTUCKY, 1854, OF ARKANSAS, 1859-60, AND OF INDIANA., 1837-33 AND 1860.

acre, "to encourage the building of ironworks and salt works, in Pulaski and Wayne Counties, which was, probably, the first appropriation made by the State toward developing the mineral resources.

Two years after Kentucky was admitted as a State in the Union, in 1790, an iron furnace, called Old State Iron furnace, and an iron foundry, were built and established in what is now Bath County (previously part of Bourbon County) to utilize the very large deposit of iron ore in that locality, which yet supplies several furnaces.

Doctor Samuel Brown, a graduate of Edinburgh and one of the first medical professors in Transylvania University, early in the present century, gave much attention to the natural history of Kentucky and contributed to the *Transactions of the American Philosophical Society* and Bruce's *Journal of Mineralogy*, a description of an unusually large niter cavern on Crooked Creek in Madison County (now in Rockcastle County); and in the first volume of Silliman's *American Journal of Science and Arts*, described the process by which the niter was made and the best theory of its formation according to the science of his day; giving, in other publications, descriptions of fossils and minerals of Kentucky.

A more remarkable explorer of early times in this State was Constantine S. Rafinesque, born in a suburb of Constantinople, in 1784. Invited to Kentucky in 1819 by his friend, John D. Clifford, who was one of the earliest promoters of natural science in the State, he was appointed professor of natural science, etc., in Transylvania University, under the Rev. Horace Halley, and in 1824 wrote the most remarkable and portentous Annals of Kentucky, which were published as a prefix to the History of Kentucky by Humphrey Marshall, in which, in only 26 duodecimal pages, he gives the geological, ethnological, and historical annals of Kentucky, from the first day of the creation according to Moses, down to the current year.

The geology and history of this singular production may be estimated by the following quotations:

> The parallel strata are formed in the following way: 1, limestone; 2, slate; 3, sandstone; 4, freestone; 5, gist; 6, pebblestone.
>
> By the operations of submarine volcanoes the strata of coal, clay, and amygdaloid are found and intermixed * * * with the above strata.
>
> The fourth period of Kentucky history (before Noah's flood) answers to the sixth day or period of the general creation.

And no one criticized this wonderful display of learning, thus illustrating the low state of science in this State in these early times.

A remarkable fact in the history of this active and visionary naturalist is that in a letter written by him to Prof. M. O. Torrey, of New York, dated December 1, 1832, he seems to have anticipated the theory of Charles Darwin as to the evolution of man, by the statement "that species, and probably genera also, are formed in organized beings by *gradual deviations of shapes*, *forms*, *and organs*, taking place in the lapse of time. There is a tendency to deviations and mutations through plants and animals by gradual steps. * * * This view of the subject will settle botany and zoology in a new way and greatly simplify these sciences. The races, breeds, or varieties of men, monkeys, dogs, roses, apples, wheat, * * * and almost every other genus may be referred to one or a few primitive species."[1]

In 1836 Dr. Samuel P. Hildreth, of Marietta, Ohio, contributed to the *American Journal of Science and Arts* (vol. 29, p. 1) a voluminous paper, Observations on the Bituminous Coal Deposits in the Valley of the Ohio and the accompanying strata, etc., 156 pages, illustrated by 36 pages of woodcut figures of fossils and sections of strata throughout the text, in which he gave many facts as to the existence of iron ore in quantity, salt water, petroleum, inflammable gas, and coal in various localities, some of which, he said, had been commununicated to him by the present writer [Dr. Peter], who at that time, being attached to the medical department of Transylvania University, had obtained most of them from the medical students who came from the several localities in Kentucky.

On December 28, 1838, W. W. Mather made a report to Governor Clark of a Geological Reconnoissance of Kentucky, in accordance with the following joint resolution of the general assembly of that State and his appointment by the governor:

> Whereas, it is important to the agricultural, manufacturing, and commercial interests of this Commonwealth that its mineral wealth and resources should be well understood and be properly developed: Therefore—
>
> *Be it resolved by the General Assembly of the Commonwealth of Kentucky*, That it shall be lawful for the governor of this Commonwealth to appoint some competent person to prepare and report to the next general assembly a plan, in detail, for a geological and mineralogical survey of this State, together with the probable annual expenses and the time necessary to complete said survey. It shall be the duty of the person thus appointed by the governor to visit the mineral regions of the State and make geological reconnoissance thereof and report to the next general assembly his views thereon, and whether, in his opinion, the expense attending such survey, as is proposed, will be compensated by the facts to be developed.
>
> *And be it further resolved*, That to enable the governor to carry into effect this resolution the sum of not exceeding $1,000 is hereby appropriated.
>
> Approved February 16, 1838.

Doctor Mather's report is comprised within 40 octavo pages, including 7 pages of a "glossary of terms." His instructions were "to make a general geological and mineralogical reconnoissance of the

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[1] From his Atlantic Journal, Extra of No. 6, Philadelphia, 1833.

State and report thereon, together with a plan in detail, with estimates, for a geological and mineralogical survey."

In this report (p. 3) he estimated the coal field in the eastern part of Kentucky at 7,000 square miles, and said that the coal measures of the western portion of the State embraced about 12 counties—"most of which is in the Green River Valley," giving also the approximate boundaries of these two great coal fields, with remarks on some of the associated iron ores, etc. "The remaining portion of the State," he remarks (on p. 4), "is mostly occupied by limestone as a substratum, and forms the richest and most productive agricultural region of the State." He described the three varieties of coal found in Kentucky—"the caking coal, the noncaking" (now called "splint or block" coal), and the cannel coal, and dwelt on the great economy of the uses of coal over wood, etc. He gave the localities of many coal beds and mines and of deposits of iron ores; among the rest a bed of "calcareous carbonate of iron 15 feet thick," near the old Buckner iron works, 5 miles southeast of Greenville (p. 9), and the celebrated bed of oolitic limonite ore (so-called dyestone ore) near Old State Furnace, Bath County, 12 to 18 feet thick (p. 17), giving credit for many facts to the Hon. David Trimble, who had recently made an elaborate report to the legislature (session 1837–38) on the Coal and Iron Interests of Kentucky.

After brief notices of the "slate formation" (Devonian shales), the niter caves, mineral and gas springs, and petroleum outflow, he passed to the limestones, which he classified as follows (p. 29):

1. The limestone beds in the coal formation.
2. The cavernous limestone, below the conglomerate and above the slate rock.
3. The great limestone below the slate.

He concluded his report with remarks on the probable beneficial results of a geological and mineralogical survey, and, in his appendix, gave his plan for conducting the same, advising the appointment of a chief geologist, and an appropriation of $12,000 a year for four years, etc.

It appears that no action was taken by the general assembly on this report.

Eight years afterward, on January 29, 1847, a "Memorial from the Kentucky Historical Society," at Louisville, by its committee, composed of L. P. Yandell, Henry Pirtle, and S. S. Goodwin, "in relation to a geological survey of Kentucky," was presented to the general assembly of that commonwealth.

In this they spoke of the great utility of such surveys and state that already 18 States in the Union had undertaken them, and gave, *in extenso*, elaborate letters on the value of such surveys, from Prof.

B. Silliman, of Yale College; Dr. C. T. Jackson, of Boston; and Dr. D. D. Owen and Dr. J. G. Norwood, of Indiana.

Doctors Owen and Norwood, in their letter, spoke of the utility of such surveys, in the information they gave as to the renovation of soils, in the knowledge obtained of valuable ores and minerals, of building materials, and as a guide to internal improvements, etc. They estimated the cost of a general survey at about $4,000 a year for three years, saying that a full detailed survey would cost much more and require more time.

Prof. B. Silliman dwelt more on the scientific benefits from such a survey, and gave no estimates.

Dr. Charles T. Jackson especially advised attention to the economical advantages.

Preoccupied by the stirring events of the war with Mexico, the legislature appears to have taken no action on this memorial of the historical society.

In 1853 a "Memorial of the Agricultural Associations of the State and Many Citizens" to the general assembly of Kentucky in an octavo pamphlet of 16 pages, with an accompanying Geological Sketch Map of Kentucky ("partly conjectured"), colored to represent the several geological formations as then known, was presented to the legislature. This memorial was signed by Benjamin Gratz, George Robertson, and Robert Peter, committee of the Fayette County agricultural and mechanical association; George W. Hancock, Philip Speed, and W. D. Gallagher, committee of the southwestern agricultural and mechanical association at Louisville; Robert Mallory, Daniel Brannin, and William S. Helm, committee of the Union agricultural and mechanical association of Shelby, Henry, and Oldham counties, and Alex. M. Brown, William C. Lyle, and G. W. Williams, committee of the Bourbon County agricultural and mechanical association.

The memorial was written by Robert Peter, who also added the map, which he colored mainly from a geological map which had been published shortly before this time by a Mr. Lawrence,[1] who had been traveling through Kentucky, making observations and lecturing on geology. This map showed, approximately, the extent of seven formations: blue limestone, gray limestone, dark slate, red sandstone, and Carboniferous limestone, Coal Measures and conglomerate, and Cretaceous—the Tertiary of the southwest corner of the State supposed at that time to be of this formation.

The memorialists respectfully urged the propriety of instituting a geological survey of the State, believing "that the prosperity of any country bears a relation to the development and improvement of its natural resources by an enlightened population"; that "no great public work promises to be more valuable to Kentucky, in proportion to the amount of expenditure required, than a thorough geological and mineralogical survey"; and that "a large body of our enlightened citizens are very desirous that such a survey should be speedily commenced."

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[1] Presumably Byrem Lawrence.

In the same year (1853) W. W. Mather made a "geological examination of the line of the (proposed) Lexington and Big Sandy Railroad, in the employ of the company, and in his report to R. Apperson, president of the railroad company, said that—

> The line of the road transverses a rich agricultural country, from Lexington to the Licking River, where it enters the mineral region. * * * The mineral materials available along the road and easy of access are: Coal, both bituminous and cannel; iron ore in numerous workable beds of great extent and good working qualities; building stones and freestones of the very best qualities in inexhaustible quantities; limestones of various qualities, adapted for making white lime and hydraulic cement, fire clay, firestone, etc.

He gave the following "table of the order of superposition of the principal masses of the rock formations:"

> Coal formation, containing common and cannel coal and iron ore.
>
> Carboniferous limestone, called the white limestone, and covered by a seam of iron ore.
>
> Fine-grained sandstone, the same as the Waverly sandstone of Ohio, so much worked in that State as fine building stone.
>
> Buff-colored limestone, contains cement rock and some beds of iron ore.
>
> Blue limestone, under the Blue Grass region.

Describing these formations in detail, he gave estimates as to the amount of their valuable deposits, to their economical uses and the business they might give to the proposed railroad.

The people of Kentucky had become greatly interested about this time in internal improvements, and the development of the mineral resources of the State, which were generally believed to be great and valuable, but the extent of which was not known, was a powerful motive in that direction.

At the next succeeding meeting of the general assembly of the State, consequently, the first act was passed, providing for a geological and mineralogical survey of Kentucky.

This and the other several acts of the general assembly, under which the geological and mineralogical survey of the State was begun and continued, under the direction of David D. Owen, during the years 1854, 1855, 1856, 1857, 1858, and 1859–60, are as follows:

Act approved March 4, 1854, to provide for a geological and mineralogical survey of the State.

SECTION 1. The governor is required, as soon as may be after the passage of this act, to appoint a State geologist, who shall be a person of competent and practical knowledge of the sciences of geology and mineralogy; and said State geologist shall, by and with the consent of the governor, appoint two suitable persons to assist him in the discharge of his duties, one of whom shall be a competent and skillful chemist.

SEC. 2. It shall be the duty of said State geologist and his assistants, as soon as may be practicable after his appointment, with as much expedition as may be consistent with minuteness and accuracy, to commence and carry on a thorough geological, mineralogical, and chemical survey of the State, with a view to determine the order and succession, relative position, and comparative magnitude of the several strata or geological formations of this State, and to discover all beds or deposits of ore, coal, and such other mineral substances as may be useful or valuable, and to analyze the same; and to perform such other duties as may be necessary to make a full and complete geological, mineralogical, and chemical survey of the State.

SEC. 3. It shall be the duty of said State geologist and his assistants to make full and complete examinations, assays, and analyses of such rocks, ores, or other substances as may be submitted to them for that purpose, and to furnish, if required, a detailed and complete account of the results so obtained; and at the courthouse of each county in this State in which he may discover valuable deposits, the said geologist shall deliver a written or verbal discourse upon their examinations, assays, and analyses of all such rocks and ores within such county; and said geologist, or his assistants, shall deposit at the clerk's office, of such county in which he may discover minerals, such specimens as he may deem of value, for the inspection of the citizens and visitors of said county.

SEC. 4. He or his assistants shall visit each county in this State, beginning with the mineral regions, to make such explorations as may be sufficient to satisfy him whether it contains mineral deposits and the extent, nature, and value thereof.

SEC. 5. They to report on or before the 1st of December in each year, accompanying the report with such maps, drawings, and specimens as may be necessary to exemplify and elucidate the same, to the governor, who shall lay the report before the general assembly.

SEC. 6. He shall forward, during the survey, such specimens of rocks, ores, coals, or other minerals, or useful matters, discovered and examined, as may be proper and necessary to form a complete cabinet of the specimens of geology, mineralogy, and other useful matters. The same shall be deposited in some convenient room in the State capitol, there to be preserved for public inspection.

SEC. 7. The sum of $10,000 is hereby appropriated, to be expended under the direction of the governor: *Provided*, The principal geologist shall not receive more than $7 a day, nor the assistants more than $5 per day each for the time they are in actual service: *And provided further*, That the appropriation herein made shall only be used, so far as the governor may find, on investigation, necessary to obtain the services of a competent geologist and assistant, during that part of the year when such geologist can profitably be employed in the prosecution of such survey.

SEC. 8. The governor shall have power to remove any persons appointed under this act for negligence or incompetence or other cause which he may deem sufficient for such removal, and to appoint others in their stead.

SEC. 9. The principal geologist and each of his assistants, before entering upon the duties of their offices, shall take oath faithfully to perform all the services required of them under this act, and to abstain from all pecuniary speculations during their progress, and that they will not conceal any valuable discovery or information from the owner or owners of the land on which such discovery is made; but in all things so conduct the survey as will duly notify the community generally, and especially the owner or owners of the land on which all such valuable discoveries are made.

An act to provide for the prosecution of the geological, mineralogical, chemical, topographical, and agricultural survey of the State. Approved by the governor, Chas. S. Morehead, March 7, 1856.

SECTION 1. The State geologist is authorized, by and with the consent of the governor, to organize two topographical corps—one to operate in the western division of the State and the other in the eastern division—in order to carry forward the geological survey with as much dispatch as is consistent with accuracy and minuteness, so as to develop the mineral resources of the State and at the same time construct geographical and geological maps, showing its geological and topographical features, commencing in the mineral regions of the State.

SEC. 2. Chemical analyses shall be made of all ores, minerals, rocks, marls, and other materials of economical value; also of the soils derived from the different geological formations, or such as may present peculiar agricultural interest; also all mineral waters to which medicinal or deleterious influences may be ascribed.

SEC. 3. It shall be the duty of the State geologist and assistants to continue the collection of all objects of geological, mineralogical, or scientific interest, to be placed in the State collection, in the southwest room of the capitol.

SEC. 4. They shall report, from time to time, to the governor, all important discoveries, who shall lay the same before the people during the session of the legislature in some public journal.

SEC. 5. It shall be the duty of the State geologist to make to the governor a full geological report of the discoveries and operations of the geological corps, which report shall be printed and laid before the legislature at their meeting in 1857–58.

SEC. 6. It shall further be the duty of the State geologist and heads of the geological corps to communicate such information, as may be obtained by them, to the citizens of the State.

SEC. 7. Ten thousand dollars per annum is hereby appropriated to be expended within the next two years under the direction of the governor: *Provided*, That the principal geologist shall not receive more than $7 per diem, nor his assistants more than $5 per diem, for each day in actual service: *And provided*, That the survey shall be carried forward simultaneously in the eastern and western mineral regions of the State by the topographical corps, while the general reconnoissance is extended over the counties not yet explored by the principal geologist.

SEC. 8. The principal geologist, or such of his assistants as he shall authorize in writing, shall have access to the records, plates, profiles, maps, field books, and notes of all surveys of roads, canals, rivers, and railroads which have been or may be made in the State, with full authority to make such copies or extracts from the same as shall be deemed useful and necessary for facilitating and expediting the geological survey of the State.

SEC. 9. So much of an act, entitled "An act to provide for a geological and mineralogical survey of the State," approved March 6, 1854, as is not inconsistent with the provisions of this act, * * * the same is hereby reenacted.

An act making further appropriation of money for the geological survey, approved by Gov. Charles S. Morehead February 17, 1858.

SECTION 1. *Be it enacted*, That the act of the last session of this general assembly on the subject of the geological survey, and the same, so far as applicable, is hereby continued in full force for the next two years.

SEC. 2 * * * That $25,000 be, and the same is hereby, appropriated, to be expended on the geological survey in the next two years, or as much thereof as may be necessary, payable out of any money in the treasury not otherwise appropriated, to be drawn by the governor's warrant on the auditor of public accounts.

SEC. 3. That said appropriation shall embrace the amount which may be found due Dr. D. D. Owen; also any balance due for printing the second and third volumes of the geological reports.

Under these several acts the work under the direction of Doctor Owen as chief geologist was carried on, including the publication of the four volumes of the geological reports of the first series.

By a letter from Doctor Owen, dated March 7, 1860, Doctor Peter was informed that the "geological appropriation had failed to pass the house of representatives," and that "Kentucky will be obliged hereafter to renew her geological survey, as it is as yet an unfinished work."

After the death of Doctor Owen, which took place in 1860, the following resolution was passed relative to the property accumulated by the survey:

Resolved by the General Assembly and the Commonwealth of Kentucky, That the attorney general of the State of Kentucky be, and hereby is, empowered and directed forthwith to adopt such measures, by suit or otherwise, as in his judgment shall be proper, to obtain for the State the immediate possession of the geological specimens, minerals, etc., in possession or under control of the late D. D. Owen, State geologist, at the time of his death, and which are the property of this State, and that said attorney general report his proceedings at the next term of this general assembly.

Approved February 4, 1861.

Expenses.—The aggregate cost of the Kentucky geological survey, during the whole term of operation under the direction of Doctor Owen, from 1854 to 1860, as given in the three several acts of the general assembly, was $55,000, distributed as follows: The appropriation for 1854–1856 was $10,000; for 1856–1858, $20,000; for 1858–1860, $25,000.

The compensation allowed to the principal geologist and his principal assistants remained as stated in the act of 1854 during the whole of his term. Other necessary employees received such wages as were determined by Doctor Owen.

Out of these appropriations was paid the cost of publishing the reports, four octavo volumes with maps and plates, in editions of 5,000 each. No pecuniary return was obtained, they having been distributed gratuitously by the members of the legislature, the officers of the survey, and other officials. This mode of distribution, placing these volumes of "public documents" generally in the hands of persons who could not fully appreciate their value resulted in the fact that at present these records are rarely obtainable by those who wish to consult them.

The cost of the publication was large. Doctor Owen wrote "that the cost of volumes 2 and 3 was $7,529.19, of which $4,600 was for binding alone";[1] and the cost of the other two volumes must have been at least as great, so that out of the $55,000 appropriated at least $30,000 must have been spent for publications.

The only officer of the survey who derived compensation from any other institution was Doctor Peter, who was also professor of chemistry in the medical department of Transylvania University, which institution materially aided the survey, without any other compensation than a collection of specimens derived therefrom, by giving the free use of its ample chemical laboratory and apparatus as well as that of its valuable scientific library.[2] The private libraries and apparatus of Doctors Owen and Peter also aided in the economy of the work.

The geological survey had no library of its own. A valuable museum of the geology, paleontology, mineralogy, the soils, etc., of Kentucky was established by Doctor Owen in a room in the capitol at Frankfort, but this was destroyed by fire November, 1865.[3]

In 1857 Doctor Owen accepted the position of State geologist of Arkansas, to take effect as soon after October 1 as his engagements in Kentucky would permit. He began operations in that State in that month, but he also continued his general supervision and direction of the survey in Kentucky up to the time of his death.

Benefits.—Doctor Owen, in the introduction to his First Report of a Reconnoissance of the Northern Counties of Arkansas, in 1858 (p. 13), giving "the results of the geological survey of Kentucky" up to that time, wrote:

> In some of the counties, where the labors of the geologist have established the existence of beds of good workable coal, the intrinsic value of the land rose, in a single season, 25 per cent all over the county, while the value of the land in many locations of the same county, offering peculiar advantages adjacent to navigable streams, rose, in the course of the same period, from $5 to $10 up to $50 and $60 per acre. And these prices have remained up to the present time, showing the valuation was real, intrinsic, and substantial.

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[1] See Reports of Geological Survey of Kentucky, vol. 4, p. 21.

[2] Transylvania University, with all its means of instruction, however, was and yet remains the property of the State, devoted to popular education, primarily endowed by the mother State, Virginia, as a "public school or seminary of learning."

[3] With the reorganization of the survey under Professor Shaler a very extensive and valuable museum of the survey was established in the capitol.

Where the simultaneous occurrence of both coal and abundant beds of rich iron ore has been proved, the rise in the value of the property has been proportionately greater.

During the whole period of the survey under Doctor Owen and up to the present day in its second epoch new beds of coal have been discovered in the detailed examination of the extensive coal fields of Kentucky. The location, the thickness, and extent, as well as the composition, character, and value of the coals are given to the public in the reports, tending continually to the development and increase of value of the comparatively unappreciated territory of the State.

This statement applies not only to the coals, but also to its associated extensive iron ores, the fire clays and plastic clays, and the limestone strata which underlie it, giving building stones, cement rock, and lime for the architect and for other purposes. The building stone of the Knob or Waverly formation, the rich limestone of the lower Silurian, yielding by its ready disintegration the blue-grass rich soil of central Kentucky; even the siliceous and aluminous deposists of the Tertiary region of the southwestern part of the State were described and their technological value ascertained and shown.

Lastly, but not least, Kentucky being mainly an agricultural State, and Doctor Owen having a predilection for agricultural chemistry, the soils of the State have been more extensively collected, analyzed, and studied in a systematic manner than those of any other territory; and the published reports of the results of these thorough and extensive examinations give very valuable information to the intelligent immigrant, as well as to the resident farmer who can read and understand them.

The immigration of skilled workers and intelligent agriculturists and the influx of capital to settle and improve the new lands, now held at prices far below their value, and the development of the rich mineral deposits of the State, measurably neglected or ignored, are thus invited, and aided and by the aid of new capital and skill public internal improvements are stimulated and manufactures of various kinds increased.

The new and accurate topographical, geodetical, and geological map of the State, with the detailed similar maps of the several counties, begun under Doctor Owen and now in progress of perfection, will be of value to the public very far above any reasonable expenditure for the same.

SECOND SURVEY UNDER N. S. SHALER AND J. R. PROCTOR, 1873–1893.

The death of Dr. D. D. Owen in 1860 and the threatened disaster of a Civil War caused the discontinuation of the first survey. The

NATHANIEL SOUTHGATE SHALER, 1873-80

JOHN ROBERT PROCTOR, 1880-91

STATE GEOLOGISTS OF KENTUCKY.

importance of the work was, however, recognized, and in March, 1872, a bill was introduced for its renewal. This was defeated in the house by a vote of—nays, 32; yeas, 43, three less than the constitutional majority. In the spring of 1873 the subject was again taken up and with more favorable results. The following is the text of an act passed at this time, and its subsequent modification and additions:

An act to provide for a geological and mineralogical survey of the State.

Be it enacted by the General Assembly of the Commonwealth of Kentucky:

SECTION 1. That the governor is hereby authorized and required, as soon as may be after the passage of this act, to appoint a State geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy; and the said State geologist shall, by and with the consent of the governor, appoint two suitable persons to assist him in the discharge of his duties, one of whom shall be a competent and skilful chemist.

SEC. 2. That it shall be the duty of said State geologist and his assistants, as soon as may be practicable after his said appointment, to commence to carry on, with such expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological, mineralogical, and chemical survey of the State, with a view to determine the order and comparative magnitude of the several strata or geological formations of this State, and to discover and examine all beds or deposits of ore, coal, flora, and such other mineral substances as may be useful or valuable, and to analyze the same; and to perform such other duties as may be necessary to make a full and complete geological, mineralogical, and chemical survey of this State: *Provided*, That the survey contemplated by this act shall be a continuation of the survey already made by Professor Owen.

SEC. 3. That it shall be the duty of the said State geologist and his assistants to make full and complete examinations, assays, and analysis of all rocks, ores, flora, or other substances as may be submitted to them for that purpose, and to furnish, if required, a detailed and complete account of the results so obtained; and at the courthouse of each county in this State, in which he shall discover valuable mineral deposits, the said geologist shall deliver either a written or verbal discouse upon their examinations, assays, and analysis of all such rocks, ores, and flora, within such county; and said geologist or his assistants shall deposit at the clerk's office of such county in which he shall discover minerals or other substances, such specimens as he shall deem of value, for the inspection of the citizens and visitors of said county.

SEC. 4. That it shall be the duty of the said geologist and his assistants to visit and make such exploration of each county in this State, beginning with the mineral regions, as will be sufficient to satisfy him whether it contains valuable minerals or other deposits, and the extent, nature, and value thereof.

SEC. 5. That is shall be the duty of said geologist and his assistants, on or about the 1st day of December in each and every year, to make a report of the progress of said survey, accompanied with maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same, to the governor, who shall lay such report before the general assembly.

SEC. 6. That it shall be the duty of the said geologist and his assistants to forward to the governor, from time to time, during the progress of said survey, such specimens of rocks, flora, ores, coal, and other mineral substances or useful materials discovered and examined, as may be proper and necessary to form a complete cabinet of the specimens of geology, mineralogy, and other useful materials of the State; and the governor shall cause the same to be deposited, in proper order, in some convenient room in the State capitol, there to be preserved for public inspection. He shall also furnish like specimens to the Kentucky University, which shall be preserved by the officers thereof, in like manner, for the use of the scholars in said university and the examination of visitors thereto.

Sec. 7. That, for the purpose of carrying into effect the provisions of this act, the sum of $10,000 be, and the same is hereby, appropriated, to be expended under the direction of the governor: *Provided, however*, The principal geologist shall not receive more than $10 per day, nor the assistants more than $7 per day each, for the time they are in actual service: *And provided further*, That the appropriation herein made shall only be used so far as the governor may find, on investigation, necessary to obtain the services of a competent geologist and assistants during that part of the year when such geologist can be profitably employed in the prosecution of such survey.

Sec. 8. The governor shall have power to remove any of the persons appointed under this act for negligence or incompetency, or any other cause which he may deem sufficient for such removal, and appoint others in their stead.

Sec. 9. The principal geologist and each of his assistants, before entering upon the duties of their offices, shall take oath faithfully to perform all the services required of them under this act and to abstain from all pecuniary speculations for themselves or others in the objects of their survey during their progress, and that they will not conceal any valuable discovery or information from the owner or owners of the land on which said discovery is made; but in all things conduct the survey, etc., as will (if practicable to do so) duly notify the community generally, and especially the owner or owners of the land on which all such valuable discoveries are made.

This act shall take effect from its passage.

Approved March 22, 1873.

An act providing for the continuation of the geological, mineralogical, and botanical survey now in progress in Kentucky, and for the prosecution of other surveys.

Be it enacted by the General Assembly of the Commonwealth of Kentucky:

Section 1. That for the continuation of the geological, mineralogical, and botanical surveys now in progress and for the prosecution of the other surveys hereinafter mentioned, there be appropriated, out of any money in the treasury not otherwise appropriated, the sum of $15,000 per annum for the term of two years, viz: $15,000 for the year beginning the first day of January, 1874, and $15,000 for the year beginning January 1, 1875, and ending December 31 of the same year, to be expended under the direction of the governor.

Sec. 2. That for the outfit of wagons, horses, and other camp equipments, together with the necessary instruments for the field and laboratory work of the survey, and for the cases necessary for the exhibition of the collections of the survey in the expositions held in our cities and at Philadelphia in 1876, as well as in the cabinets provided for at Frankfort and Lexington, and for the expenses of persons employed to exhibit and supervise the same, together with all other expenses incidental thereto, there be, and is hereby, appropriated, out of any money in the treasury not otherwise appropriated, such sums, not to exceed $3,500, as the governor may, from time to time, direct.

SEC. 3. That the State geologist be authorized and required to institute a survey of the water powers of the State, to determine their value and position; that he also be required to make or have made a sufficient study of the fishes of the State, so far as the means of the survey will admit; that he be also required to cause to be examined and reported on the other animals of the State which may be of economic or scientific importance.

SEC. 4. That the cost of the publication of the results of the survey be made out of the appropriation specified in the first section of this act: *Provided, however*, that the time of publication and the number of copies printed shall be determined by the governor, it being required that all important reports shall be stereotyped or electrotyped, and the plates thereof remain the property of the State.

SEC. 5. The director of the surveys shall be allowed to withdraw from the State library any books on geological subjects which he may find necessary for the prosecution of the surveys. He shall also have the right of access to all railway, river, canal, or other maps within the State, for the purpose of copying the same, as far as may be necessary for the work of the suvey.

SEC. 6. The director of the surveys shall be empowered, from time to time, to publish in any suitable journal the scientific or economic results of his surveys, it being provided that all discoveries of economic value shall first be published in the journal most likely to give the people concerned information.

SEC. 7. That the State geologist be authorized to organize three topographical corps, by and with the consent of the governor, one in the western division of the State, one in the southern division, and one in the eastern division, in order to carry forward the geological survey with such dispatch as is consistent with accuracy and minuteness, so as to develop the mineral resources of the State; and at the same time construct geographical and geological maps, showing its geological and topographical features; and that the topographical corps shall carry forward the work simultaneously, commencing such surveys in the mineral regions of the State, while the geological reconnoissance is extended over the counties not yet explored by the principal geologist.

SEC. 8. That so much of an act entitled, "An act to provide for a geological and mineralogical survey of the State," approved March 22, 1873, as is not inconsistent with the provisions of this act be, and the same is hereby, reenacted.

This act shall take effect from and after its passage.

Approved, February 13, 1874.

An act to provide for continuing the geological and other surveys of the State of Kentucky.

Be it enacted by the General Assembly of the Commonwealth of Kentucky:

1. That the geological and other surveys of the Commonwealth, provided for and ordered by the acts approved, respectively, March 22, 1873, and February 13, 1874, be, and the same are hereby, continued, subject to the conditions set forth in these enactments, except so far as is hereafter provided.

2. That the maps, reports, and other publications of the survey shall be disposed of and distributed as follows: One copy shall be given to each member of the State government, and three copies, for distribution in their respective counties, to each member of the general assembly; one to each county and circuit clerk's office, to be filed and retained therein as the property of the State, and to be retained therein for information and reference by the citizens of said county; five copies to each officer of the survey engaged in the preparation thereof; 300 copies shall be distributed to the various public libraries and other

public institutions and men of science in this and other countries in the manner most likely to diffuse knowledge of the resources of the State and to aid in developing its industries; that the remainder of the copies printed from time to time shall be offered for sale, as may be directed by the governor of this Commonwealth, at the actual cost of printing, binding, and distributing the same.

3. For the maintenance of the surveys, as above provided, there is hereby appropriated, from any moneys in the treasury not otherwise appropriated, as follows: For the further geological investigation of the State, including the salaries of the director and his geological assistants, and their field expenses, $6,000 per annum; for the topographical survey, including the salaries of assistants, and field expenses, $4,000 per annum; for the salaries of the chemical assistants and their office expenses, $3,000 per annum; for the preparation of stereotype and lithographic plates, and presswork, paper, and the other expenses of printing the reports, maps, etc., $7,000 per annum: *Provided*, The printing and binding authorized by this act shall be duly advertised and let to the lowest responsible bidder, under the direction and supervision of the governor and director of the survey. For the outfit, expenses of the survey, the purchase of horses and wagons, instruments, etc., and for office expenses, $1,000 per annum; for the purchase of cases, and the expense incident to collections at the State cabinet and elsewhere, as provided and declared in the act approved March 22, 1873, $1,000 per annum: *Provided, however*, That the money not required for any of the purposes specified above may be used for the other specified purposes; and no part of the amount set apart for plates, printing, etc., shall be used for any other purpose until the publication shall be fully completed.

4. This act shall take effect from and after its passage, and expire at the end of two years from and after passage.

Approved February 19, 1876.

By an act of April 5, 1878, providing for the continuation of the survey, the amount allowed for geological investigation, including the salaries of the director and his assistants and their field expenses, was reduced to $3,600 a year; for chemical analyses and other laboratory work there was allowed $900; for engraving of maps, plates, and other illustrations, $900; for stereotyping, $1,700; for office expenses and collecting of specimens, $600; and for outfit expenses, $400: "*Provided always*, That the money not required for any of the purposes specified above may be used for other specified purposes."

The law for the distribution of the reports remained substantially as in the act of 1876: Provided, that the first edition of the reports and other publications of the survey should not exceed 1,000 copies, the governor, however, having authority to order at his discretion subsequent editions of 500 copies each: "*Provided*, That the photographs published shall be in editions of not exceeding 100 copies, of which 50 copies shall be placed in public libraries in this and other countries as may seem most likely to disseminate information concerning the Commonwealth, and the remainder shall be sold at the cost of making and distributing the same."

By the act of April 26, 1880, the amount appropriated for geological investigations, including the per diem of the director "whilst actually engaged in the direction of the survey," and the salaries of his assistants and their field expenses was $4,000 a year; for the continuation of the topographical survey and the work on the State map, $2,000; for chemical analyses, $600; for research concerning building stones, $250; for the examination and report upon the water power of the State, $500; for the expenses of the office of the survey immigration and the State cabinet, $500; and for the continuing of the photographing of the State, $500.

Sections 4 to 6 of this act provided, further:

> 4. That the governor shall, at this and each regular meeting of the legislature, appoint a State geologist, by and with the advice and consent of the senate, for the term of two years, or until his successor is appointed and qualified, who shall reside at Frankfort, and be there at all times when not engaged in the necessary surveys, and who shall also be a commissioner of immigration. Said commissioner shall attend to the office work of the survey, and, in addition thereto, he shall collect, compile, publish, and circulate, in such manner and by such agencies, and in such places as he may deem proper and advisable, in the United States and in foreign countries, pamphlets and other publications descriptive of the resources and advantages of this State, and such other facts and information having a tendency to attract and promote immigration, and otherwise use his discretion in the furtherance of immigration, and the bringing of skilled labor and capital into the State. He shall also collect and disseminate such information as in his judgment will best aid in the founding of industries to utilize and manufacture within the State raw products of the State. That the reports of said commissioner, when presented to the governor and approved by him, shall be printed by the public printer, at the same charges and upon the same terms as similar work is done for the State.
>
> 5. Said commissioner shall keep in his office a record of lands for sale, lease, or colonization, which record shall be kept accessible to all persons inquiring for such information as it may contain; and he shall be allowed a fee of $2 for making each entry or record, to be paid by the owner of the land so recorded, which fee shall be used to hire the necessary clerical aid to make the records, and assist in the correspondence of the office.
>
> 6. Said commissioner shall not, during his term of office, either directly or indirectly, have any interest in any real estate agency or land speculations.

The legislature of 1882 passed an act for the continuation of the survey, in which the amounts appropriated vary slightly from those just given, as shown in the tabulation on page 123.

The duties of the State geologist remained the same, though a clause was inserted into section 4 of the act providing that the State geologist should be required to keep an account of all moneys paid out in his department in a book kept for that purpose, and to be at all times open to inspection to the members of the general assembly and other State officials. A final clause to the section provided that the printing done should be paid out of the fund therein appropriated.

Section 5 of the law of 1882 further provided that no fee should be allowed for entry or recording the sale of lands, nor should any fee or commission be charged by said bureau on lands so recorded which might be sold to immigrants.

The act of 1884 continuing the survey was essentially the same as that of 1880, with some changes in the amount appropriated and with additional strictures forbidding the State geologist and his assistants to have any financial interests in matters relating to transactions of their office.

The act of 1888 for the continuation of the survey provided that the geologist should not receive more than $10 a day during such time as he was in actual service, and that the total salaries received by him should not exceed $2,000 a year: also that the geologist should execute a bond in the sum of $20,000 to the Commonwealth of Kentucky, with good and sufficient surety, for the lawful discharge of his duties. It also further provided, under section 3 of this law, that the governor should have power to remove any of the persons appointed for negligence or incompetence: also section 8 provided that the geological survey should be extended first to the counties in the State which have had no survey and next to the counties which have had the least survey made.

The law of 1890 appropriated the sum of $15,000 a year for two years, to be expended in the same manner as indicated in the law of 1883–84. excepting that nothing therein should be construed to appropriate money for an immigration bureau, or "for any purpose except for geological, topographical, and agricultural survey of the State; chemical analyses of soils, coals, ores, and other substances; the collecting of and testing of coals, clays, building stones, ores, and other substances." It also provided that any money received from the sale of publications should be placed in the State treasury to the credit of the general revenue. Otherwise there was no change of importance.

Administration.—Under the act of 1873 N. S. Shaler, a native of Kentucky, but at the time professor of paleontology in the Lawrence Scientific School of Harvard University, was made director, entering upon his duties on August 22 of that year. With the assent of the governor, Dr. Robert Peter, of the Kentucky University, was appointed chemist and A. R. Crandall, geological assistant. Doctor Peter was assisted by Mr. J. H. Talbutt, and Mr. Crandall by P. N. Moore, J. A. Monroe, C. W. Beckham, and C. Schenk—a total of eight persons, at an average cost of $1,200 a month, including salaries, chemical supplies, subsistence, transportation, and repairs. The salary of the director was by law limited to $10 a day and that of the assistants to $7 a day for the time they were actually in service.

The plan for the conduct of the survey noted above consisted of:

1. A general reconnoissance of the ground in order to secure the outlines of the problems which have to be met.

2. The formation of an accurate topographical map, which should give, on the scale of at least 1 inch of map distance for every mile of country, the exact relations of every stream, hill, and valley throughout the State.

3. A geological survey which should be so exact as to indicate, on colored sheets of this map, the precise limits of each formation, so that the owner of any land, by the use of his map, and the accompanying diagrams and reports, might be able to determine, as nearly as possible, what lies beneath it.

4. A careful study of living animals and plants within the State, in order that their usefulness to man, the means of their nurture or destruction, and their relation to the fossil life, shown by the geological survey, may adequately be determined.

5. The study of the physical conditions existing in the State—climate, magnetic variations, etc.

6. The presentation of this knowledge in such fashion that may be best suited to secure its preservation and ready use within the State, and its dissemination abroad.

7. The extension of the study of science within the State.

With a view of accomplishing a maximum amount of work within the limits of the appropriation, a letter was addressed to many of the State senators and representatives, asking each to name, from his own county, some person willing to make himself a volunteer agent of the survey. As a result of this the following volunteer corps was organized: J. R. Anderson, Rev. Dr. Colby, Prof. Failes, W. O. Graves, W. T. Knott, J. M. Litton, A. B. Lyman, M. Powell, Colonel Rand, Thomas Turner, and R. Twyman. Subsequently, and for varying periods, the following were added: C. J. Norwood, J. B. Marcou, H. Herzer, W. M. Linney, assistants in geology; W. B. Caldwell, assistant in mineralogy; W. B. Page, W. C. Mitchell, E. Underwood, and J. B. Hoeing, assistants in topography; A. S. Packard, assistant in entomology; F. Sanborn, assistant in zoology; F. W. Putnam, assistant in ichthyology; J. Bussey, assistant in botany; Lucian Carr, assistant in ethnology; L. Trouvelot, artist; and A. L. Jones.

The class of information the volunteer corps was expected to furnish is indicated by the following 10 queries:

1. What are the defects in the representation of your county on the maps you may have in hand? County lines, streams, and roads, how far are they in error?

2. What are the mineral springs, or springs remarkable on account of their temperature, volume, variability, etc.?

3. What are the minerals, coals, and building stones, as far as known? What mines, salt wells, and quarries have been opened? And what was the yield of these materials last year?

4. What caverns exist in your county?

5. What are the principal points where good sections through the rocks can be seen?

6. What are the principal varieties of soils in your county, their natural timbering, crops, and the regions occupied by them?

7. What are the timber trees, and how are they distributed in the county?

8. What are the water powers of your county, size of streams, character of shore, etc.?

9. What is the price of land according to the character of soil, productiveness, and availability for immigration purposes?

10. What remains of ancient races exist in your county?

The survey as first organized had no immediate connection with other institutions, although its director was at the time professor of paleontology at Harvard University in Cambridge, Massachusetts, and its chief chemist was professor of chemistry at the State agricultural college at Lexington. An unofficial connection was made with Harvard through the establishment by Professor Shaler of a summer school of geology, the first sessions of which, through an invitation by Governor Leslie, were held in Kentucky. Mr. John R. Proctor, assistant on the survey, was employed by the university to superintend the summer camp, the number of students in which was limited to 30. The survey was put to no expense in connection with the school, the advantage gained by the school being the permission extended to the students of accompanying the parties in the field to observe the method of work and, incidentally, to profit by the knowledge of the assistants. In exchange for this the survey was relieved of the expense of maintaining its own camp and of transportation, and received the assistance of such members of the school as were capable of doing useful work. Sessions of the school were thus held during the seasons of 1875, 1876, 1878, and 1879.

In April, 1880, Professor Shaler, through pressure of other duties, was compelled to resign as director, and was succeeded by the former assistant, John R. Proctor. The plan of procedure under Mr. Proctor was outlined as follows:

1. A topographical and geological survey of the two coal fields of the State; obtaining information of the area, thickness, position, character, and quality of the various strata of coal and iron ores, clays, etc.; studying the relation of same to available transportation routes, and also with existing resources in adjacent States; also a study of the kinds, quality, and distribution of the timbers; the water powers; the character of the soils, and the adaptability of these soils to certain branches of agriculture, and the suitableness of the same for immigration; to make the above known to the world by carefully prepared and accurate statements of facts.

2. The making of such a survey of the various counties of the State as will best promote agricultural development; the analyses of the soils, subsoils, and underclays of the various geological horizons; the coloring of these horizons on the map, in a manner to enable the agriculturist to make practical use of the results obtained. This work I believe to be of fundamental importance, affecting, as it does, the well-being and prosperity of a large majority of our people.

3. In connection with the above the chemical and laboratory work; analyses of soils, clays, coals, iron ores, mineral waters, and other substances collected by the geological survey; the practical testing of the coking quality of coals and testing of clays, etc.

4. Topographical work; the making of county maps, and coloring the geology on the same; the completion of an accurate map of the State. The necessity for a correct map of Kentucky can not be overestimated, none having ever been made.

5. The collection, in the State cabinet, of specimens of the coals, iron ores, building stones, clays, and other substances, showing the resources of the State; also a collection of the fossil remains from the various strata, and the arrangement and classification of the same in a manner best calculated to afford instruction to persons wishing to gain information on such subjects.

6. The office work; preparation of reports for publication; reading of proof; preparation of geological sections and illustrations; drawing of maps and coloring same; conduct of the large correspondence of the survey, etc.

7. Work connected with the bureau of immigration, placed by law under the geological survey.

Museum and library.—The formation of collections to illustrate the resources of the State was advocated, one of the several collections to be deposited in the State University at Lexington, another at the capitol, and yet another for general exposition purposes. These were to illustrate—

1. The geological and mineralogical features of the country.
2. Its soils and their cultivated productions.
3. Its native animals and plants.
4. Its ancient life, both of animals and man.

A valuable reference library is stated to have been accumulated, but without cost to the State.

Results.—Under the administration of Proctor the results enumerated below were claimed as having been accomplished:

In western Kentucky the topography and geology have been completed over 13 counties, aggregating an area of 4,870 square miles; and in addition the topography has been completed and the maps drawn ready for the geologist, or for the engraver, if it be decided to print them without the geology, of nine counties in western Kentucky, aggregating 3,564 square miles.

Geology and topography have been completed in 17 counties of central Kentucky, aggregating 4,826 square miles.

Topography has been completed, and geology partially completed, over five counties in south central Kentucky, aggregating 1,829 square miles.

Geology and topography have been completed over an area aggregating at least 10,000 square miles in the eastern coal field.

Thus, since the beginning of 1880, there have been completed—

	Square miles.
In western Kentucky, geology and topography	4,870
In western Kentucky, topography only	3,564
Total	8,434
Central Kentucky, geology and topography	4,826
Eastern Kentucky	10,000
South central Kentucky	1,829
Grand total	25,089
To the above add completed work done by the second survey prior to 1880; eastern Kentucky, 4 counties, geology and topography completed (see 1, map No. 1, accompanying this report)	1,070
Nolin River district, geology and topography completed (see 4, map No. 1)	264
Topography completed, parts Menefee, Wolfe, etc. (see 7, map No. 1)	580
Topography Grayson, Hancock, and part of Ohio County (see 6, map No. 1)	550
Total	2,464

The above does not include the mass of preliminary work done prior to 1880, such as sections across the western coal field; nor does it include the work done by the survey under the direction of Dr. David Dale Owen.

Appropriations by the Assembly for the Shaler-Proctor survey, 1873–1893.

By act approved:		
Mar. 22, 1873		$10,000
Feb. 13, 1874	[1] $15,000	[2] 30,000
Feb. 19, 1876—		
For geological research, including salaries and field expenses	6,000	
For topographical survey, including salaries and field expenses	4,000	
For chemical assistants and expenses	3,000	
For expenses incidental to publication	7,000	
For outfit for field work and office expenses	1,000	
For cases and collecting for State cabinet	1,000	
	[1] $22,000	44,000

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[1] Annually for two years.

[2] An additional appropriation of $3,500 was made to pay the expenses of the survey's exhibit at Philadelphia in 1876.

Appropriations by the Assembly for the Shaler-Proctor survey, 1873–1893—Con.

Apr. 5, 1878—		
For geological research, etc., as above	$3,600	
For chemical analyses, etc., as above	900	
For expenses of publication	900	
For stereotyping	1,700	
For office and collecting expenses	600	
For field outfits	400	
	[1] $8,100	
		$16,200
Apr. 26, 1880—		
For geological research, as above	4,000	
For topographical survey, as above	2,000	
For chemical analyses, etc	600	
For researches on building stone and clay	250	
For research on forestry resources	250	
For reseach on water power	500	
For office and collecting expenses[2]	500	
For photographing	500	
	[1] $8,600	
		17,200
Apr. 1, 1882—		
For geological research	4,000	
For topographical survey	2,500	
For chemical analyses	600	
For office and collecting expenses	500	
	[1] $7,600	
		[3] 15,200
Apr. 19, 1884—		
For geological research	6,800	
For topographical survey	3,600	
For chemical analyses	1,000	
For office expenses and collecting	700	
	[4] $12,100	
		36,300
Apr. 16, 1888. For all expenses as per act of 1884	[4] 15,000	30,000
May 26, 1890. For all expenses as per act of 1884	[4] 15,000	30,000
Total		$228,900

In his report for 1878–79 Professor Shaler had recommended the continuation of the survey as a "combined survey and bureau of industries," with the function of bringing together detailed information concerning the natural products of the State and aiding the founding of industries, a line of work which had already been forced upon the officers of the existing organization. It was presumably this recommendation, in part, which caused the legislature, in April, 1880, to create a bureau of immigration and place the same under the direction of the State geologist.

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[1] Annually for two years.

[2] Includes also office expenses of Bureau of Immigration.

[3] In addition there was appropriated the sum of $5,000 annually for the Bureau of Immigration.

[4] Annually for three years.

By this act, and in the capacity of ex-officio commissioner of immigration, the geologist was required to "collect, compile, publish, and circulate in such manner, and by such agencies, and in such places as he may deem proper and advisable, in the United States and in foreign countries, pamphlets, and other publications descriptive of the resources and advantages of the State, and such other facts and information as will have a tendency to attract and promote immigration and the bringing of skilled labor and capital into the State."

The work accomplished along these lines lies beyond the limits of the present history. It is well to note, however, the statement of Mr. Proctor in his report for 1886–87 to the effect that the legislature, while making of him mandatory requirements by the creation of this bureau, made no provisions for the carrying out of the same without trenching upon the appropriations of the survey, and at the same time the amount of the appropriation was the smallest that had thus far been made. It would appear, therefore, that the amalgamation was decidedly to the detriment of the work for which the survey was originally created.

From the annual reports and subsequent legislation it would appear that matters relating to the survey were not conducted in a manner altogether satisfactory to the governor and to the assembly. Thus, under date of January 15, 1892, it was—

Resolved by the General Assembly of the Commonwealth of Kentucky:

1. That the President of the Senate appoint a committee on geological survey, to be composed of five members, which shall act with the house committee on geological survey, and constitute a joint committee, whose duty it shall be to inquire into and report—(1) What amount of money, and for what purpose, has been expended out of the appropriation made by the last general assembly. (2) What amount of said appropriation remains unexpended. (3) What amount of field work, including the kind and locality thereof, has never been begun. (4) What field work already begun needs completion, including the cost required to complete it. (5) Whether or not the advantages which may accrue to the commonwealth justify a continuation of the survey. (6) If survey is not continued, what disposition should be made of the cabinet, library, and archives of the department. (7) Any other matter which the committee may deem proper; and (8) report such bill or resolution in relation to the survey as the committee may deem wise and for the best interests of the commonwealth.

2. This resolution shall, on account of emergencies hereby declared to exist, take effect from its adoption.

It appears, further, that on April 30 of this year the State inspector and examiner made a report to the governor unfavorable to Mr. Proctor's management of the finances of the survey. This was replied to by the geologist in a letter subsequently privately printed and circulated under the date of May 24, but it was apparently without effect so far as the life of the organization was concerned, and on August 16 we find the following:

Resolution in relation to the geological survey.

Be it resolved by the General Assembly of the Commonwealth of Kentucky:

1. That the auditor of public accounts is hereby directed to collect and place into the treasury to the credit of the general expenditure fund the sums of money in the hands of John R. Proctor, Robert Clarke & Co., and Flexner & Staadeker arising from the sale of publications of the survey, as shown by report of State inspector and examiner, made at the present session to the president of the senate.

2. This resolution shall take effect from its adoption.

Approved August 16, 1892.

This was succeeded by the following resolutions and enactments, the intent of which is obvious, and the survey came to a somewhat inglorious end in 1893:

An act for the benefit of the employees of the geological survey.

Be it enacted by the General Assembly of the Commonwealth of Kentucky:

1. That, as the sum now remaining to the credit of the geological survey is insufficient to meet all demands that can legally be made against the same, the auditor of public accounts be, and is hereby, directed to audit, and, upon the approval of the governor, pay from the balance on hand, and from any other sum in the treasury not otherwise appropriated by law, all legal demands against said survey for salaries due its officials, or expenses legally incurred by them in connection with said survey: *Provided, however*, That no official connected therewith shall receive a greater sum for his services than was allowed by law at the time the services were rendered; and no claim shall be allowed for any salaries or expense after the expiration of their terms of office on the 26th of May, 1892.

2. That as it is necessary that the claims against the survey should be paid, an emergency is hereby declared to exist, and this act shall take effect from and after its approval by the governor.[1]

Resolution providing a curator for the cabinet and other property of the gelogical survey.

Be it resolved by the General Assembly of the Commonwealth of Kentucky:

1. That the inspector of mines, in addition to his other duties, shall be *ex officio* curator of the cabinet and other property of the geological survey, and into whose care and keeping all the records, documents, collections, instruments, apparatus, books, maps, and other property of the survey are hereby confided, and which shall become a part of his office.

2. All persons having control or possession of any of said property, or the rooms formerly designated or occupied for the use of the survey, are hereby directed to surrender the possession thereof to the curator.

Approved June 20, 1893.

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[1] Became a law February 4, 1893, the governor not having signed or returned the same to the house in which it originated within the time prescribed by the constitution.

An act to amend a resolution entitled "Resolution providing a curator for the cabinet and other property of the geological survey," approved June 20, 1893.

Be it enacted by the General Assembly of the Commonwealth of Kentucky:

1. That a resolution, entitled "Resolution providing a curator for the cabinet and other property of the geological survey," passed by the general assembly of 1893, be, and the same is hereby, amended by striking out all of section 1 of said resolution, which reads as follows: "That the inspector of mines, in addition to his other duties, shall be *ex officio* curator of the cabinet and other property of the geological survey, and into whose care and keeping all the records, documents, collections, instruments, apparatus, books, maps, and other property of the survey are hereby confided, and which shall become a part of his office," and substituting in lieu thereof the following words:

"1. That the inspector of mines, in addition to his duties as such inspector, shall be curator of the cabinet and other property of the geological survey or department, and all the records, documents, collections, instruments, apparatus, books, maps, and other property of the survey are hereby confided to his care and keeping; and, as such curator, he is hereby required to attend to all correspondence and respond to all requests concerning the mineral resources of the State that come to him in his said capacity; to attend to the distribution of all published maps and reports in his hands intended for distribution; and to perfrom all the duties devolving upon such a curator, so far as is applicable in this case; and he shall whenever the general assembly shall direct and provide therefor, cause to be printed, under his supervision, any or all of the unpublished reports of the geological survey that may be in his custody. He shall be allowed and paid $50 per month as compensation for his services as such curator, and shall give bond for the faithful performance of his duties as such curator, with surety to be approved by the governor.

2. The compensation, provided for in section 1 of said resolution, as amended herein, shall begin only with the date of the approval of this act.

3. It being just and proper that the compensation provided for in section 1 hereof shall become available at once, since said inspector is now, and has been for several months, performing the extra duties of curator, as provided for herein, an emergency is hereby declared, and this act shall take effect on its approval by the governor.

Approved March 15, 1894.

LOUISIANA.[1]

FIRST SURVEY UNDER EUGENE W. HILGARD AND F. V. HOPKINS, 1869–1871.

The first step taken by State authority toward a general survey of the geological structure and industrial resources of Louisiana occurred during the latter part of the war of the Confederacy, under an executive order of Gov. H. W. Allen, made early in 1864. This order authorized Judge John B. Robertson, of New Orleans, to begin a systematic investigation of the agricultural, mineral, and manufacturing resources of the State. Judge Robertson took with him on the expedition "Mr. Charles Tripp, a competent mineralogist and metallurgist; Mr. John H. Jones, a skillful ironmaster of 35 years' practical experience; and Capt. John Roy, a most intelligent and practical machinist and artisan," and explored various portions of the State in search of iron and other minerals. Judge Robertson was engaged for 16 months in these duties, after which he was authorized to make a visit to the Calcasieu region for the purpose of investigating the reported discovery of petroleum and the geological structure of the region.

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[1] Mainly from manuscript by E. W. Hilgard.

Judge Robertson transmitted his report (covering 25 octavo pages) to the legislature of the State at its session in January, 1867, and at the same time submitted a memorial suggesting that further and more comprehensive and active investigations of this character were called for by public exigencies, but made no direct proposition for the organization of the State survey. Report and memorial are both printed in the volume of reports of the legislature for 1867. No action save that of printing the report seems to have been taken by the legislature at this time.

The ideas advanced concerning the geology of the region examined were naturally somewhat crude. There is given, first, a general statement regarding the physical aspect of the State. Then a discussion is entered into relative to the prairies, the alluvial area, and the marshes. Under the head of "Geology" the author stated:

> A short distance beyond the Teche an older formation begins, extending over the broad prairies of the Attakapos, Opelousas, and Calcasieu, merging into the Tertiary and even secondary formation in central and northern Louisiana. Stratification of stone is rare, though beds of stratified limestone, conglomerate and siliceous sinter are here and there found; while successive layers of lignite underlie much of the slate. Vast hills, sometimes over 200 feet in height, have been upheaved by volcanic action, and are covered with fragments of red sandstone formerly stratified.[1]

The "five islands" are then described and are also considered to be of volcanic origin. The deposit of rock salt of Petite Anse is mentioned, and in connection therewith the salines of north Louisiana and their deposits of bones.

The iron region of Louisiana is then mentioned as being very extensive. North of the Red River it was noted as extending from the Washita to the Bodcau, and from the Arkansas line to within a few miles of Red River, while south of Red River it was said to cover large portions of De Soto, Natchitoches, Rapides, and Sabine Parishes. In north Louisiana the iron ore is said to be so abundant as absolutely at some points to obstruct agriculture. "Vast crops of rich ores may be seen piled up in the fields."

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[1] The hills here alluded to are regarded by Prof. E. W. Hilgard as evidently those capped by the characteristic ferruginous sandstone of the Lafayette or Orange sand, the curiously suggestive concretionary formations of which have given rise to a great deal of speculation among the natives, and are often compared to the ruins of a forge. See Report on the Geology and Agriculture of Mississippi, 1860, p. 9.

The usual reports of the finding of lead and copper were then alluded to; then, briefly, the limestones, more or less clay and ochres occurring at various points, notably under the saliferous soils on Lake Bistineau.

Gypsum was mentioned as occurring in the salines of north Louisiana; also soda springs, from which, during the war, baking soda was boiled by the inhabitants.

Lignite and peat were also discussed, and finally petroleum, which at that time had excited high expectations in some portions of the State.

In November, 1865, Prof. Richard Owen, then acting as colonel of an Indiana regiment stationed at New Iberia, cursorily examined the geological features of Petite Anse, with a view to determining the age of the rock-salt deposits there occurring. His conclusions were substantially to the effect that the theory of a volcanic origin of the islands was wholly unfounded, and that the salt bed was probably the result of evaporation of modern sea water forming the lagoons behind the protecting ridges and filled during periods of exceptionally high tides.

In 1866 two points in the geology of Louisiana were referred to Prof. E. W. Hilgard for investigation. One was the determination and discussion of the fossil material taken from a well bored at New Orleans in 1866 at a depth of 230 feet, specimens of which had been collected by a committee of the New Orleans Academy of Sciences and placed at the disposal of the chief of engineers, A. A. Humphreys. The second was an examination of the geological position and relations of the rock-salt deposits of Petite Anse, above referred to. This latter proposition was made by Prof. Joseph Henry, secretary of the Smithsonian Institution, with an offer to defray the necessary traveling expenses out of the Smithsonian fund. Other duties compelled Professor Hilgard to defer the examination of this deposit to the succeeding year, but he made a preliminary examination of the fossils from the New Orleans well, which were found in the main to agree with the marine species then living in the Gulf.

In November, 1867, in pursuance of a renewed offer of assistance from the Smithsonian Institution, Professor Hilgard undertook the investigation of the geological relations of the Petite Anse salt deposit, the solution of which involved a general examination of the ancient and modern deposits, as well as the delta formations of the Mississippi Valley and adjacent coasts. Beyond the fact that the salt deposit underlaid and was, therefore, anterior to the Lafayette formations, and was not an accidental lagoon deposit, as had been previously conjectured by Professor Owen, no clew to its real age could be found. Professor Hilgard was, however, unwilling to let the matter rest with this unsatisfactory conclusion, and continued to agitate the subject of a more extended examination of the geological features of the State, both as a matter of general interest and also in order to determine whether the great salt deposit might be expected to be accessible at other points, and if so, where.

The discovery of the great sulphur bed, which was reached in boring for petroleum in the coast region of Calcasieu, increased the public interest in the subject, so that almost simultaneously the problem of the geological structure of Louisiana was attacked from two sides. On the one hand, the New Orleans Academy of Sciences, aided by an appropriation of public funds by the State immigration bureau, requested Professor Hilgard to undertake a general geological reconnoissance of the State. On the other hand, the State legislature, by an act approved March 6, 1869, made an appropriation of $1,000 to defray the traveling expenses of two professors of the University of Louisiana (then located at Alexandria under the designation of the Louisiana State Seminary of Learning and Military Academy) in making a general geological and topographical survey of the State, under the direction of the superintendent of that institution. The following is the text of this act:

An act to provide for a topographical and geological survey of the State of Louisiana

SECTION 1. *Be it enacted by the Senate and the House of Representatives of the State of Louisiana in General Assembly convened*, That it shall be the duty of the board of supervisors of the Louisiana State Seminary of Learning and Military Academy to require the professor of engineering and the professors of chemistry, mineralogy, and geology to spend not less than four months of every year in making jointly a topographical and geological survey of the State of Louisiana till the whole work is completed to the satisfaction of the legislature.

SEC. 2. *Be it further enacted, etc.*, That it shall be the duty of said professors of engineering and chemistry to make, on the 31st day of September of each year, detailed reports, with the necessary maps, diagrams of their survey to the superintendent of said institution, and that it shall be the duty of said superintendent to forward said reports, with his own annual report, to the board of supervisors for transmittal to the legislature in the annual report of said board.

SEC. 3. *Be it further enacted, etc.*, That it shall be the duty of the superintendent of said institution to consider the typographical and geological survey of the State as herein provided for, as part of the regular duties of said institution, and to superintend the same accordingly.

SEC. 4. *Be it further enacted, etc.*, That said professors of engineering and chemistry, etc., be allowed each the sum of $500 for necessary traveling expenses while in the performance of said duties, to be paid to the treasurer of said institution on the warrant of the president or vice president of said board of supervisors.

SEC. 5. *Be it further enacted, etc.*, That this act shall take effect from and after its passage.

Administration.—Under this act Profs. E. W. Hilgard and F. V. Hopkins were designated to undertake the work, receiving therefor no compensation beyond their professional salaries. Messrs. Scott Miller and J. R. Walker accompanied Professor Hilgard in the capacity of assistants, while Professor Hopkins was assisted by S. H. Lockett, of the same institution, who took charge more especially of the topographical part of the work.

The results of Hilgard's work were discussed in an article entitled Summary of a Late Geological Reconnoissance of Louisiana, published in the *American Journal of Science* for November, 1869, and also in a more popular form in *De Bow's Review* for September, 1869.

From the sale of the outfit of the expedition there was obtained a sum sufficient to defray the expenses of some chemical work on the materials collected, which work was performed at the University of Mississippi by Dr. R. H. Loughridge.

The final report, of 44 pages, including a full discussion of the entire subject matter of the expedition, was published in 1873 at New Orleans, under the auspices of the New Orleans Academy of Sciences. The edition consisted of but 200 copies.

Professor Hilgard's connection with the survey ended with the publication of the report above mentioned. Professor Hopkins, however, continued the work, his second annual report forming part of the report of the superintendent of the State University for 1870. Under his recommendation, made in the previous report, the legislature's appropriation for the survey had been increased and some compensation for their vacation work allowed the professors engaged therein. The exact amount of this increase and the terms in which the provision was made have not been ascertained, but the total appropriation did not exceed $3,000.

The third series of survey reports (for the year 1871), and bearing the imprint of the *Republican* office, 94 Camp Street, New Orleans, 1872, likewise formed part of the report of the superintendent of the State University.

These reports terminated the publications of the State geological survey of Louisiana. In 1872 there occurred political changes, as a result of which the university for the time being ceased operations, and the faculty, who had for some time been serving without pay, in consequence of the low value of the State treasury warrants, dispersed. As a matter of fact, the expenses of the last survey operations had been paid out of their own pockets. These expenditures, together with their salaries for about the same time, were never repaid, either by the university or the State. The collections made

CHARLES THOMAS JACKSON

STATE GEOLOGIST OF MAINE, 1837-39, RHODE ISLAND, 1839-40, AND NEW HAMPSHIRE, 1839-43.

by Lockett, Hopkins, and Featherman remained at the university building at Baton Rouge.

The only additional geological work done in Louisiana under Government auspices prior to that since inaugurated by the United States Geological Survey and the State experiment station was a rapid reconnoissance made in 1880 by Dr. R. H. Loughridge. then acting as special agent of the Tenth Census, under direction of Professor Hilgard. In 1892 the work was resumed under the direction of the experiment station at Baton Rouge, and is still continued with an annual appropriation from the State of $5,000, which sum is expended for salaries, field expenses, and publications. From 1892 to 1894 the field operations were carried on by Otto Lerch, who was succeeded by W. W. Clendenin, and the latter, in 1899, by Gilbert Harris.[1]

MAINE.

FIRST SURVEY UNDER CHARLES T. JACKSON, 1836–1839.

Organization.—Maine was set off from Massachusetts and organized on a basis of independent statehood in 1820. The first attempt at a public survey was made in connection with Massachusetts for the purpose of ascertaining the possible resources of the public lands. The act of organization, so far as Maine was concerned, was passed March 21, 1836, and was as follows:

> *Resolved*, That the governor, with the advice of the council, is hereby authorized to employ some suitable person or persons to make a geological survey of any lands in Maine, where such survey, together with the various observations which the surveyors will have opportunity to make, will probably lead to a more accurate knowledge of the worth of the public domain.

This was supplemented on the 28th of the same month by the following:

> *Resolved*, That (in the language of our chief magistrate) a geological survey of this State, upon a basis commensurate with the magnitude and variety of its territory, is an enterprise that may rightfully claim the encouragement of every class of industry, as involving more or less of probable utility to each and is intimately connected with the advancement of the arts and sciences, of agriculture, manufactures, and commerce.
>
> *Resolved*, That the board of internal improvements cause a geological survey of this State to be made as soon as circumstances will admit, commencing in the early part of the next summer, and they are hereby empowered to appoint and contract with some suitable person or persons to perform the same.
>
> *Resolved*, That it is with pleasure we learn the intention of Massachussets to join us in prosecuting so much of said survey as shall pertain to the public lands; that we cordially embrace the opportunity of cooperating with her in this design; and that the board of internal improvements are hereby directed

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[1] See Preliminary Report on the Geology of Louisiana, by G. D. Harris and A. Veatch. Baton Rouge, Louisiana, 1899, pp. 11–44.

to take such measures as may be necessary to effect this portion of the contemplated survey.

Resolved, That it shall be the duty of the board of internal improvements to lay before the legislature, at its annual sessions, a detailed account of the progress of the survey, together with the expenditures in prosecuting the same.

Resolved, That the person who shall be employed to make the geological survey, shall be required to select three complete suites of specimens of all the rocks and minerals of Maine and deposit one of them in the public buildings as the property of the State and also one in each college in the State.

Resolved, That the sum of $5,000 be appropriated from the treasury, subject to the discretion of the board of internal improvements, and to be expended by them in carrying on said geological survey.

It being found impossible to complete the survey during the first year, the following resolution was passed in March, 1837. for its continuance:

Resolved, That the governor, with the advice of council, is hereby authorized to employ some suitable person or persons to continue the geological survey of the State at a salary not exceeding $1,000.

Resolved, That the sum of $3,000 be appropriated from the treasury of the State, subject to the direction of the governor and council, and to be expended in continuing said geological survey.

Resolved, That in addition to the suites of specimens ordered by a former resolve, suites shall be collected for the following institutions, viz: One suite for the Maine Institute of Natural Sciences, one suite for the Maine Wesleyan Seminary, one suite for the Westbrook Seminary, one suite for the Parsonsfield Seminary, one suite for the Eastport Athenaeum, one suite for the Bangor Mechanics' Association, one suite for the Teachers' Seminary of Gorham, and one suite for the Maine Charitable Mechanic Association.

Resolved, That it shall be the duty of the governor and council to lay before the legislature, at its annual sessions, a detailed account of the progress of the survey, together with the expenditures in prosecuting the same.

At the close of the second year's work, namely, in March. 1838, the legislature passed a resolution to continue the survey as follows:

Resolved, That the governor, with the advice and consent of council, is hereby authorized to employ some suitable person or persons to continue the geological survey of the State at a salary not exceeding $1,500 per annum.

Resolved, That the sum appropriated for this purpose shall be subject to the discretion of the governor and council, and be expended in continuing said survey.

Resolved, That it shall be the duty of the governor and council to lay before the legislature at its next annual session a detailed account of the progress of the survey together with the expenditures in prosecuting the same.

The immediate motive for the establishment of the survey of 1836 was the exploration of the public lands belonging jointly to Maine and Massachusetts, but, by the act of March 28, the scope was broadened so as to include a geological survey of the entire State.

Administration.—In compliance with the resolutions of 1836, the following order was issued by the board of internal improvements June 25, 1836:

Ordered, That Messrs. Hodgdon, Pillsbury, and Burnham be authorized to contract with Charles T. Jackson, of Boston, to commence the geological survey of the State, subject to the instructions of the president of this board, in pursuance of a resolve of March 28, 1836.

Doctor Jackson received his commission from Governor Dunlap of Maine on July 18, 1836, and from Gov. Edward Everett of Massachusetts on the same date.

Jackson was assisted during 1836 by Dr. T. Purrington, of Brunswick, Maine, and James T. Hodge, of Massachusetts; during 1837, by J. T. Hodge and W. C. Larabee; and 1838, by Samuel L. Stephenson, of Portland, and Ariel Wall, of Hallowell, the appointments being made with the consent of the governor's council.

The dual nature of the survey made necessary the rendering of reports to the governors of both States, those relating exclusively to the public lands being addressed to the chief executive of Massachusetts, and those of the more comprehensive State survey to that of Maine.

The first report of the public lands survey appeared in the form of senate document No. 89, printed at Boston in 1837, under the title of First Report on the Geology of the Public Lands Belonging Jointly to the States of Massachusetts and Maine, an octavo pamphlet of some 47 pages. The second report was issued as house document No. 70, Boston, 1838, and consisted of an octavo pamphlet of 93 pages.

Jackson's first report as State geologist appeared under date of 1837, as did the report on the public lands. It formed an octavo pamphlet of 127 pages. The second report appeared in 1838—an octavo pamphlet of 168 pages: and the third and last in 1839, comprising 276 and lxiv pages.

The character of the information furnished in all these reports was necessarily somewhat fragmentary. Much of the country was covered by dense forest and could be traversed only by boats on the larger streams.

The first reports on the public lands dealt mainly with the country along the northeastern boundary, a territory nearly as large as that of the State of Massachusetts. Doctor Jackson gave a somewhat general account of the mineral resources and topography, while Mr. Hodge, in the second report, gave a description of the geology of the land in the vicinity of Mount Katahdin and the region of the Aroostook, Penobscot, the Alleguash, the St. John, and the St. Francis rivers. There was also a chapter on the agricultural geology and the agricultural resources of Maine, and a table of barometric and thermometric observations.

The reports of the State survey proper naturally duplicated in large part, for the first two years, those of the public-land surveys. That of 1837 announced the general plan of the survey, the first great object being to ascertain the geological boundaries of the State. This was effected as follows:

> The seaboard from Lubec to Thomaston was carefully examined so as to determine the nature and position of the different rocks. Then the St. Croix was explored and the line followed onward to Houlton. From that place we proceeded to the St. John River, and pursuing its western bank, we obtained a section of the strata, which cross the public lands, and crop out along the source of that river. At the Grand Falls we took canoes and examined the rocks and soils to the Madawaska River. By following this plan * * * we have made a reconnoissance of two sides of a very large square, forming the eastern and northern boundaries of the State.

Some 64 pages of the report were given up to a description of the topographical geology, as then determined, and 30 pages to economical geology. The second annual report was likewise divided, the first 100 pages being given up to the topographical geology, 42 pages to economical geology, and 25 to agricultural geology. The third and last comprised 122 pages of geological matter, 65 relating to agricultural matters, a report by Dr. S. L. Stephenson on explorations of the Androscoggin and Megalloway rivers, and appendices giving a list of barometric measurements and a catalogue of specimens in the State cabinet.

Collections and library.—The acts of 1836, 1837, and 1838, relating to the survey, all provided for the making of collections to be distributed among the various educational institutions of the State. These provisions seem to have been faithfully carried out, and, according to Jackson's statement in his third annual report (1839, p. 6), there was deposited in the statehouse at Augusta a collection of not less than 1,600 "handsome specimens of rocks, minerals, and soils of the State, all arranged, labeled, numbered, and described in a complete catalogue." In addition to this 10 other smaller but representative collections were prepared for the colleges, academies, and societies, as provided by law. Owing to lack of care the collection in the statehouse was allowed to become sadly confused and in part lost, and a similar fate apparently befell the others with the possible exception of the one presented Bowdoin College. No library was established in connection with the survey.

The typical set placed in the statehouse was removed from the position in which it was originally placed to make room for other things. The specimens were thrown promiscuously into boxes, and as a result the labels on many of them were destroyed or lost and the specimens themselves worthless. To add to the confusion, the catalogues accompanying the collection disappeared, so that but little is now left to represent the money and talents expended in its preparation.

In order that the few specimens still remaining from the general wreck might be preserved as far as possible from utter destruction the legislature of 1888–89 passed an order as follows:

> *Resolved*, That the superintendent of public buildings be, and hereby is, authorized and directed to transfer and remove the geological specimens, now stored in the basement of the capitol building, to Colby University, Waterville, Maine; and that the governor and council be authorized to draw a warrant for the necessary expenses attending such removal. Said university as far as it may be within the power of the officers of its geological department so to do, shall arrange and classify said specimens, label them with a card bearing the words, "State Geological Collection," place them on exhibition during the entire college year, answer all questions in reference to the same, addressed to said department by the people of the State, and in general shall take all the care and precaution which scientific institutions usually exercise in the preservation of such specimens. Said specimens to remain the property of the State, subject to the order of the legislature.

In accordance with this resolution all the specimens stored in the statehouse were transferred to Waterville and placed in the possession and under the care of Colby University.

The reports of the survey were distributed in accordance with the following resolutions approved March 29, 1837:

> *Resolved*, That there shall be copies of the First Report of the Geological Survey of Maine distributed in the following manner, viz: Twelve copies to the governor of the State; one copy to each member of the council, senate, and house of representatives; one copy to the secretary of state, treasurer, land agent, and adjutant general; one copy to the secretary, assistant secretary, and messengers of the senate; one copy to the clerk, assistant clerk, and messengers of the house of representatives; 100 copies of the report and 50 copies of the plates to the governor and council, to be by them distributed; two copies to each of the colleges in the State; one copy to the theological institution at Bangor; one copy to each of the incorporated literary institutions and academies in the State; one copy to the Maine Medical School; one copy to the Maine Historical Society; one copy to the Maine Institute of Natural Science; one copy to each of the incorporated agricultural societies in the State; 12 copies to the geological surveyor; three copies to each of his assistants and three to the draftsman; five copies to the library of the State; one copy to each of the clerks in the several departments of this State; one copy to the executive of each of the States in the Union; one copy to each of the colleges in New England except those in this State; one copy to the American Academy of Arts and Sciences; one copy to the Antiquarian Society in Worcester (Mass.); two copies to the library of the United States; one copy with the plates to the surveyor general of this State; one copy with the plates to each chaplain of the senate and house of representatives.
>
> *Resolved*, That two copies of the report and one copy of the plates shall be distributed to each of the cities, towns, and organized plantations, and the remainder of the edition of reports and plates shall be equally divided among the

senators and representatives, to be by them distributed among the people in their several school districts or otherwise, according to their discretion.

Benefits and Results.—As a principal result of his operations Doctor Jackson states:

> The public lands have been augmented in value by spreading information abroad respecting their nature and capability of cultivation. The value of individual property, the aggregate of which forms the sum of the State wealth, has been greatly increased; new resources have been discovered, and the extent and value of those but little known have been ascertained and reported. Mines and minerals which, when wrought, will bring a large capital into the State, will serve to relieve the community generally by creating more taxable property, and thus removing a share of the public burthen from the shoulders of every individual. Materials now imported at a high cost will be produced at a cheaper rate within the limits of the State and domestic industry, skill, and capital will be brought forward. Iron and glass may be manufactured advantageously in Maine, and these two articles are of more general use and require more expenditure than any others imported into the State. It will be hereafter a matter of astonishment that Maine ever had to import her iron and glass as much so as that she formerly did not supply her citizens with bread. Slate quarries, equal if not superior to those of Wales, have lain neglected in Maine for ages, while the houses of Portland, Bangor, and even the statehouse itself are covered with foreign slate.
>
> Since a new demand for lime has been created for agricultural use, it became very important to know whether the interior of the State possessed valuable beds of limestone, for it is evident that the farmers could not use lime extensively on their soil unless it could be obtained at a low price. We are enabled to point out immense and inexhaustible supplies of this useful substance, in the very regions where it is most required, and to demonstrate its capability of answering for every ordinary use.

In concluding, he adds:

> Maine has already gained great credit for her liberal views in undertaking a geological survey of the State, and so important has the work proved to the community generally that it is to be hoped that she will carry it forward to its full completion.

A final appendix to this report is a catalogue of 1,566 specimens that had been collected by the members of the survey and deposited in the statehouse for exhibition. As already noted, smaller collections had been presented to Bowdoin College and to the other educational institutions mentioned in the resolution of 1837.

Although Doctor Jackson had called attention to the fact that he had been able to do no more than make a very superficial examination of the geology of the State and to lay a foundation upon which more exact knowledge might be erected, the legislature, nevertheless, decided to let the matter rest, so that nothing more was done in the interest of the subject for the next 23 years. In the meanwhile the collections which had been made with so much trouble and care were neglected, as already noted.

SECOND GEOLOGICAL (AND NATURAL HISTORY) SURVEY UNDER BOARD OF AGRICULTURE AND C. H. HITCHCOCK, 1861–1862.

In 1861, under the influence of the board of agriculture, a scientific survey of the State was established. The following is the transcript of the act of March 16 of that year:

Resolved, That the governor, with the secretary of the board of agriculture, is hereby authorized to contract with some suitable person or persons to conduct a scientific survey of the State; said survey to embrace its geology, agriculture, natural history, and physical geography.

Resolved, That the person or persons who shall conduct this survey shall analyze soils, minerals, or other deposits whenever such may be found of a character demanding minute and careful investigation into their characteristics and economical value.

Resolved, That the person or persons so employed by the State shall collect and prepare for deposit in the public buildings, specimens illustrative of the geology, agriculture, and natural history of the State.

Resolved, That the person or persons so employed in prosecuting this survey shall be required to present to the legislature, on or before the third Wednesday of January in each year, a report of his or their proceedings and progress, together with such suggestions as may be deemed useful, which report shall be published in connection with and incorporated in the annual report of the secretary of the board of agriculture.

Resolved, That the sum of $3,000 be appropriated from the treasury, to be expended under the direction of the governor and secretary of the board of agriculture in prosecuting said scientific survey.

The legislature of the year following (1862) appropriated a like amount for its continuation.

Administration.—This survey was placed under the direction of Ezekiel Holmes, of Winthrop, as naturalist, and Charles H. Hitchcock of Amherst, Massachusetts, as geologist, who received their commissions on May 23. The assistants were George L. Goodale, of Saco, botanist and chemist; J. C. Houghton, Still River, Massachusetts, mineralogist; A. S. Packard, jr., of Brunswick, entomologist; and C. B. Fuller, of Portland, marine zoologist. Messrs. Houghton and Packard were obliged to discontinue their services at the end of the first year, owing to the smallness of the appropriations. The following instructions were issued regarding field work:

As an outline of operations for the present year we recommend as follows: That, commencing operations the 1st of June, you proceed, by rapid reconnoissances, to examine as much of the western and coast lines of the State, as may be practicable, by the 10th of July, more particularly with a view to ascertain the kind, breadth, and direction of the geological formations which may be found, in order to establish a basis or border line of delineation of a geological map of the State, that, on or about July 10, you repair to the more settled portions of Aroostook County, investigating its geology, natural history, agriculture, and physical geography, with especial reference to the resources and capabilities of the public domain in that section: thence to the slate and iron regions of Piscataquis County, making similar investigations; thence to the Penobscot River and up the east branch thereof to its head waters; thence across to the Allegnash River or other tributary of the St. John, and down said river to Fort Kent; thus visiting a section hitherto unknown to scientific exploration.

The reports of the survey submitted to the governor under the title Preliminary Report upon the Natural History and Geology of the State of Maine, were published in the reports of the secretary of the board of agriculture for 1861 and 1862, comprising 356 and 447 pages, respectively. As might be expected from the organization of the survey, these embraced a general report on the natural history, agriculture, and geology of the State, and a special report upon the physical geography, agricultural capabilities, geology, botany, and zoology of the wild lands. Geological maps of the northern and eastern portions of the State, in black and white, accompanied these reports. A large map (colored) was also deposited by Professor Hitchcock in the statehouse at Augusta. This map furnished the data afterwards utilized by Walter Wells in his report on the hydrography of the State.

Collections and library.—The intention of the various acts establishing both surveys was, as is apparent, to form collections which should be sent to the various institutions of learning. This intention was only partly carried out, however, and, so far as can be learned, those collections which were made by the Jackson survey have been largely ruined, with the exception of the one in Colby College and the smaller one in Bowdoin College, as already noted. The collections made by the several members of the Holmes-Hitchcock survey were deposited in the rooms of the Portland Society of Natural History, and from these suites of specimens were to be selected for presentation to the various colleges and other institutions of learning within the State, but this was never done; and unfortunately, the collections were lost in the fire that destroyed the society's buildings in 1866. A few of the fossils which had been withdrawn for study are now in the American Museum of Natural History, New York. No library was formed in connection with this survey.

Expenses.—The expenses of the survey, other than those of publication, appear to have been met in full by the appropriations mentioned—$3,000 a year for two years.

Publications.—The following list includes all the publications of the various surveys:

First Report on the Geology of the Public Lands, belonging jointly to the States of Massachusetts and Maine. By C. T. Jackson. Sen. Doc. No. 89. Boston, March 25, 1837. 47 pp.

Second Annual Report on the Geology of the Public Lands, belonging to the two States of Massachusetts and Maine. By C. T. Jackson. Boston, 1838. House Doc. No. 70. 92 pp.

JULIUS TIMOLEON DUCATEL, 1835

WILLIAM BULLOCK CLARK, 1896-1917

STATE GEOLOGISTS OF MARYLAND.

First Report on the Geology of the State of Maine. By C. T. Jackson. Augusta, 1837. 127 pp.

Second Report on the Geology of the State of Maine. C. T. Jackson, Augusta, 1838. 168 pp.

Third Annual Report on the Geology of the State of Maine. C. T. Jackson. Augusta, 1839. 275 pp.

Preliminary Report upon the Natural History and Geology of the State of Maine. 1861. E. Holmes and Chas. H. Hitchcock. 458 pp.

Second Annual Report upon the Natural History and Geology of the State of Maine. 1862. E. Holmes and C. H. Hitchcock. 447 pp.

MARYLAND.[1]

FIRST GEOLOGICAL SURVEY UNDER J. T. DUCATEL, 1833–1842.

Organization.—The inception of the first geological survey of Maryland dates from 1833, when resolutions relative to a State map and geological survey were passed by the general assembly upon the 6th and 16th of March. Several earlier attempts looking toward the same results had been made, but were all defeated.

The particular resolutions referred to above seem to have been the outgrowth of an agitation by Messrs. William Patterson, Robert Gilmore, and the Maryland Academy of Sciences and Literature. A series of resolutions and a memorial bearing upon the subject were drawn up by the gentlemen mentioned and transmitted to the senate, and by that body referred to the house of delegates, in the following terms:

JANUARY 19, 1833.

Gentlemen of the House of Delegates:

We beg leave to refer to your consideration the accompanying memorial of William Patterson and others, as a survey of the State has been made at the present session an object of inquiry in your honorable body. The memorial now transmitted being designed to lead to a development of the mineral resources of the State, and to a collection of information of great interest to the general good and to individual enterprise. We respectfully submit it for the special attention of your honorable body.

By order,

(Signed) J. H. NICHOLSON, *Clerk.*

In pursuance of the same object, a memorial of the Maryland Academy of Science and Literature was also brought before the house of delegates, on Tuesday, March 5, 1833, by Mr. Louis W. Jenkins: "Recommending that a geological survey of the State may be made under public authority." This was made the subject of a "special order" for March 16, and at that session the report of the senate relative thereto was read twice, concurred in, and the "resolution therein contained was assented to and sent to the senate."

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[1] Mainly from manuscripts by P. R. Uhler.

A few days later, on March 18, 1833, "the resolution relative to a geological survey, severally endorsed, assented to," was passed and became a law. The following is the text of these resolutions:

Resolution relative to the State map.

Resolved by the General Assembly of Maryland, That the governor and council be, and they are hereby, authorized to appoint a competent engineer, whose duty it shall be to examine and collect all the information, plats, and reports of surveys, for canals or railroads, or other public works, which have been made by or under the authority of this State, or any company incorporated by the State, or under the authority of the corporation of Baltimore; and the said engineer shall make and report to the governor and council, before the next session of the general assembly, a plan and drawing for a complete map of Maryland, and such portions of adjacent States as may be necessary to show the position of Maryland, in reference to the great valleys and streams in her immediate vicinity, the practicable routes for plans of internal improvement; and the said engineer shall make further examinations and surveys as shall be requisite, for the purpose of exhibiting the prominent geographical and typographical features of the country; and also to collect such statistical information as will be useful, and is generally exhibited on modern improved maps; and the governor and council shall allow such reasonable compensation for the services to be rendered under this resolution as in their judgment may be just and reasonable.

Resolution relative to a geological survey.

Resolved by the General Assembly of Maryland, That the governor and council be, and they are hereby, authorized to appoint an assistant to the engineer to be appointed on the subject of a State map, whose duty it shall be to act in conjunction with said engineer, and the said assistant shall make the necessary geological researches, and report to the governor and council, before the next session of the general assembly, upon the expediency and probable cost of the geological survey of the State; and the governor and council shall allow such compensation for the services to be rendered under this resolution, as in their judgment they may deem just and proper.

The following year the foregoing resolution was expanded and reenacted in a form which was intended to cover all that was most important in relation to the map and survey, as well as the kind of officers to be employed, and the way in which their duties were to be performed. The following is a copy of the act and its instructions as passed by the legislative session of 1834:

An act to provide for making a new and complete map and a geological survey of this State. Passed February 25, 1834.

SECTION 1. *Be it enacted by the General Assembly of Maryland*, That the governor and council be and they are hereby authorized and required annually hereafter to appoint and commission a person of talents, integrity, and suitable scientific attainments as topographical engineer for the State of Maryland, and also to appoint and commission in like manner a competent and suitable person as geologist for the State of Maryland, and the said officers shall each receive, in consideration of the faithful performance of their respective duties, an annual salary of $2,000, to be paid as the salaries of the other civil officers of the State are or may be directed to be paid.

SEC. 2. *And be it enacted*, That it shall be the duty of the engineer to be appointed as aforesaid to proceed with all due and reasonable diligence and care to collect the necessary information and make all the necessary surveys and locations to enable him to make a perfect and complete map of the State according to the plan and drawing prepared and submitted to the executive of the State by J. H. Alexander, Esq., under and in pursuance of a resolution of the generaly assembly, passed at December session, 1832, and the said engineer shall, as soon as conveniently he can, make perfect and complete the said map.

SEC. 3. *And be it enacted*, That it shall be the duty of the geologist to be appointed as aforesaid to make a complete and minute geological survey of the whole State, commencing with that portion which belongs to the Tertiary order of geological formations and with the southern division thereof, and progressing regularly with the course of the waters of the Potomac and Chesapeake through that region, and thence through the other subdivisions of the State, with as much expedition and dispatch as may be consistent with minuteness and accuracy; and he shall prepare and lay before the legislature at the commencement of every session a detailed account of all remarkable discoveries made and the progress of the work.

SEC. 4. *And be it enacted*, That it shall further be the duty of the geologist of the State, at those seasons not suited to the active prosecution of the geological survey, to analyze and ascertain the qualities and properties of all specimens of mineral substances or soils left at his office or residence for that purpose by any citizen of the State and taken from any portion of the territory of the State.

SEC. 5. *And be it enacted*, That it shall be the duty of the topographical engineer to indicate upon the new map of the State the localities of valuable mineral deposits already known or which may in the progress of the geological survey be discovered, and, as far as conveniently may be, to indicate also, by references to marginal notes or otherwise, their several natures, qualities, and values; and for this purpose the geologist of the State shall keep him regularly advised of all important discoveries which he may make and the material facts in relation thereto and the said engineer shall report to the legislature at the commencement of every session the progress he shall have made during the preceding year in the work assigned to him.

SEC. 6. *And be it enacted*, That for the purpose of facilitating and expediting the completion of the said map and geological survey of the State, the governor and council be and they are hereby authorized to allow and pay the accounts of said officers, for necessary contingent expenses other than personal, so far as they may deem said accounts just, equitable, and proper, to an amount not exceeding $1,000 in any one year.

SEC. 7. *And be it enacted*, That the officers to be appointed under and by virtue of this act shall be subject to the orders of the executive of the State to make any surveys for canals, railroads, or other works of internal improvement which the legislature may at any time direct to be made: *Provided, nevertheless*, That this act shall expire at the termination of the next session of the general assembly unless the same shall be reenacted by the next legislature of this State.

This was continued in force until February 24, 1842, when the survey was abolished and the offices of topographical engineer and geologist made vacant by special legislative enactment, as follows:

Be it enacted by the General Assembly of Maryland, That the act entitled "An act to provide for completing a new map and geological survey of this State," passed at December session, 1834, chapter 230, be and the same is hereby repealed, and the offices of topographical engineer and geologist of this State be and the same are hereby abolished and discontinued.

Sec. 2. *And be it enacted*, That the said topographical engineer and geologist aforesaid be and they are hereby authorized and required to deliver to the visitors and governors of Saint John's College, subject to any further dispositon thereof by the State, all mathematical instruments, books, and all and every description of property whatsoever which may have been purchased, from time to time, out of the contingent fund appropriated to facilitate and expedite the completion of the said map and geological survey, in prosecution of their several duties as topographical engineer and geologist aforesaid.

Administration.—In accordance with these resolutions [of 1833], Messrs. J. T. Ducatel, geologist, and J. H. Alexander, engineer, were appointed to conduct the survey. In carrying out the provisions of the resolution under which they were appointed, they conjointly made a general reconnoissance in 1833 of the whole State and embodied their observations in a report to the governor, dated December 27, of that year.

For convenience the territory was divided into five sections, of which the first to be examined was the eastern shore or peninsula lying between the State of Delaware, the Atlantic Ocean, and the Chesapeake Bay. Its agricultural interests were assumed to be of primary importance, and consequently a minute investigation of the mineral constitution of the soil and careful research into the nature and extent of the natural fertilizers contained within its limits claimed their attention. Observations were recorded of that part of the country lying between the Ells River and the southern part of Worcester County.

The second great division embraced that portion of territory lying beyond the upper part of the Tertiary formation and within a line drawn from northeast to southwest, passing along the summit of Parrs Spring Ridge, and comprising the upper part of Cecil County, the greater portion of Baltimore and Harford counties, the upper division of Anne Arundel County, and the whole of Montgomery County.

The third division coincided with the limits of Frederick County.

The fourth, that of Maryland Falls, embraced the whole of Washington County and the part of Allegany County as far as Cumberland.

The fifth and last comprised the remaining portion of Allegany County west of Wills Creek.

With this much in the way of preliminary, the geologist began his investigations by proceeding, as soon as the season would permit, to the Eastern Shore of Maryland, where he made a survey of Talbot, Caroline, and Queen Anne's counties and later in the season crossed to southern Maryland, where he surveyed the shore of the Potomac in Prince George and Charles counties. Much attention was devoted to the marl deposits of the area visited.

In 1835 he revisited the Eastern Shore and made geological examinations of Dorchester, Somerset, and Worcester counties, and later of St. Marys County, a full account of which he gave in the report for that year. This report also contained the first announcement of the existence of green-sand marl in Kent and Cecil counties.

In 1836 the geologist completed the survey of Calvert County and extended his observations into Anne Arundel, Prince George, and St. Mary's counties, where he likewise announced the discovery of extensive marl deposits.

A special visit was made to Allegany County, and in his report for the year an account is given of the Frostburg Basin, with its coal and iron deposits.

In 1837 the survey of Kent, Cecil, and Montgomery counties was completed. The results of the investigations were published in the report of that year, accompanied by topographic maps prepared by Mr. Alexander, and upon which the leading matters of geological interest were noted.

In 1838 he made a survey of Harford County, and in his report gave a statement regarding its mineral resources, together with a general outline of the geology of both Harford and Baltimore counties, with some remarks on their agricultural condition. To this report he also appended a treatise on lime burning.

In 1839 he completed investigations in Frederick and Carroll counties and prepared an account of their resources and agricultural conditions for his report of the operations of that year.

In 1840 his operations were confined largely to Washington and Allegany (including Garrett) counties, his report for that year including chapters on the physical geography, geology, and mineral resources of the State. This report was accompanied by a topographic map on the scale of 1:400,000, with a geological profile of the Cumberland and National roads. Additional plates gave a sectional profile of the ore beds worked at Lonaconing, and also a section near the center of the Georges Creek basin. This pamphlet constituted the last report of the State geologist, although the office was not abolished until February, 1842.

During the first year of the survey the topographical engineer, according to the wording of the law, was to make a survey for canals, railroads, or other works of internal improvement which the legislature might at any time direct. Under this ruling he was compelled to cooperate, immediately after his appointment, with an engineer from Virginia and commissioners from Delaware in the location of a canal on the Atlantic borders of Worcester County. He found time, however, to perfect a plan for extensive cooperation with Mr. Hassler, the chief of the United States Coast and Geodetic Survey, in the conduct of the topographic survey of Maryland. Through the adoption of this plan he hoped to be put in possession of tried instruments, and it was expected the work would be completed with more despatch and at less expense than if left to be prosecuted with such means alone as he could otherwise command.

During 1835 the topographical engineer continued his surveys in connection with various plans for further internal improvements, which interfered with the preparation of the new State map. In addition to several maps which were prepared for special surveys he, however, completed a topographical map of Dorchester, Somerset, and Worcester counties, on the scale of 1:211,200, with 4-foot contour lines, and a similar topographical map of St. Marys, Charles, and a part of Prince Edward counties on the scale of 1:200,000, with 10-foot contour lines. Both of these maps had geological data placed upon them and were published in the report of the State geologist.

During 1836 the engineer was repeatedly engaged in the conduct of special surveys which had been authorized by distinct resolutions of the legislature, so that he was still further retarded in the prosecution of his work upon the State map. Among those published in his annual report for this year, however, is a detailed map of the Frostburg region and another of northern Frederick County, as a basis for the proposed railroad from Frederick to the Pennsylvania line. A topographical map of Calvert County with part of Anne Arundel County was also published in this report.

Impressed with the impossibility of successfully prosecuting the topographical survey under such conditions, Mr. Alexander in a letter to the governor recommended the postponement of the work upon the new map of Maryland until it could be undertaken in connection with the United States Coast and Geodetic Survey, in accordance with the plan of cooperation which had been earlier effected with Professor Hassler. He still continued, however, to prepare special maps for the reports of the geologist, between 1837 and 1840, and also compiled an admirable topographical map of the State upon the scale of 1:200,000, with 50-foot contour lines to the east and 100-foot contour lines to the west of the Monocacy River. This map was never published in full. The date of this map is not stated, but it was thought to have been probably completed shortly prior to 1840.

Mr. Alexander made no reports between the years 1837 and 1840, but in 1841 he presented a brief statement regarding the "trigonomical survey for the new map of Maryland," in which he urged the taking up of the plan of cooperation with the Coast and Geodetic Survey, as earlier arranged, but which had been hindered, up to that time, because the national bureau had been largely concerned with surveys to the north of Maryland.

The abolition of the office of engineer at the same time with that of geologist, in February, 1842, put an end to these operations.

Publications.—The first report submitted by the survey was the result of the joint efforts of Ducatel and Alexander. Their later reports were made separately, each official working with greater independence toward the purposes for which he was appointed.

The second report was completed and sent to the governor under date of December 29, 1834, forming a pamphlet of 50 octavo pages, accompanied by two maps. Subsequent reports were issued under dates of December 29, 1835; December 26, 1836; December 26, 1837; 1838; 1839; and 1840.

The report of 1840 was prefaced by a letter to the governor, in which a plea was made for an extension of time, suggesting that the proper completion of the work demanded further attention in order to bring all the materials collected into such a form as would prove most useful to the State. The plan suggested was as follows:

To furnish a detailed account of the physical geography of Maryland; of her agricultural condition and resources in the several counties, together with her agricultural statistics; of her geology, scientific and economic, the former illustrated by maps and sections; of her mineral resources and their statistics, also according to counties; to which was appended a geographical and geological map of the State, embracing the latest surveys.

This appeal to the governor and legislature was unheeded; the cry for retrenchment in the expenditure of public moneys prevailed, and the survey came to an end.

Expenses.—The cost of the survey, from its beginning in 1833 until its termination in 1841, amounted altogether to $17,909.42. This sum does not include any part of the salary paid to the topographical engineer for work upon the State map, nor for surveys in connection therewith. The annual salary paid to the geologist was $2,000, and he was allowed $500 for contingent expenses incidental to his work.

In December, 1847, the office of State agricultural chemist was created for the benefit of the farmers of the State, and James Higgins, M. D., was appointed by the governor to fill the position.

The following is a transcript of this act:

An act entitled An act to provide for the appointment of an agricultural chemist for the State.

SECTION 1. *Be it enacted by the General Assembly of Maryland*, That the governor, by and with the advice and consent of the Senate, shall hereafter annually appoint and commission a person of ability, integrity, and suitable practical and scientific attainments, as agricultural chemist for the State; and if the Senate shall have adjourned before the Governor shall make the appointment for the present year, or if a vacancy shall hereafter occur during the recess of the senate, then the governor alone shall make such appointment, which shall be good and valid until the tenth day after the meeting of the senate.

SEC. 2. *Be it enacted*, That the State shall be divided into three districts: The first shall comprise that part of the State now comprised in the first gubernatorial district; the second, that of the third gubernatorial district; and the third, that of the second gubernatorial district.

SEC. 3. *Be it enacted*, That the said agricultural chemist shall spend one year, the first beginning on the date of his appointment, in each of the said districts in the order named; it shall also be his duty to spend one month in each county, and Howard district, and visit each election district.

SEC 4. *Be it enacted*, That it shall be the duty of said agricultural chemist to analyze specimens of each variety of soil of the county in which he shall be, that may be brought to him or that he may find to exist, and also to examine, and, if necessary, analyze, specimens of each kind of marl, or other vegetable or mineral deposit, that may come to his knowledge, in order that his instructions may be of more practical utility.

SEC. 5. *Be it enacted*, That it shall also be his further duty to deliver one public lecture, after having given timely notice thereof, in each election district in each county, and then to deliver a course of public lectures at each county town, and at some central place in Baltimore County, after having given also sufficient notice thereof in each election district; and he shall also permit the clerk of the levy court, or the commissioners of tax, as the case may be, to take a copy of such course of lectures, to be retained and kept for the use and benefit of the county, and published by said levy court or commissioners of the tax, if to them it shall seem expedient.

SEC. 6. *Be it enacted*, That the said chemist shall make an annual report to the house of delegates, if in session, and, if not, then to the governor, whose duty it shall be to cause the same to be published, of his proceedings, and such other matters, touching the agricultural interest of the State, as may be considered necessary.

SEC. 7. *And be it enacted*, That for the faithful discharge of his duties the said chemist shall receive the annual salary of $1,500, to be paid as the salaries of other officers are or may be paid; and for the purchase of chemical instruments and materials the said chemist shall be allowed for the first year the sum of $200 in advance, and on each succeeding year a sum not exceeding $50, out of such moneys as may be in the treasury not otherwise appropriated.

This office, although not a geological one, is deemed of sufficient interest to be noted here. The entire amount expended from the creation of the office in 1847 till the expiration of Doctor Higgins's term in 1858, including the salary of the State chemist ($1,500 a year), appears to have amounted to $19,239.03. An allowance was made in 1858, however, for $500 additional for expenses, to which he had been subjected in the prosecution of his official duties.

During the session of the general assembly of 1858 Mr. Anthony Kimmel brought a bill before the senate to have the title of chemist changed to "geologist." A substitute was offered to make it "chemist and geologist," but neither change was favorably received and the bill was defeated by a strong opposing vote.

In accordance with the law as originally enacted, Mr. Philip Thomas Tyson was chosen by the governor to fill the place made vacant by the resignation of Doctor Higgins in 1858. Mr. Tyson's first report, bearing date of December 28, 1859, was printed in an edition of 5,000 copies by the legislature of 1860, and the number increased on the 14th day of February by the Senate ordering 3,000 copies for its own use.

The second report, sent to the house of delegates January 11, 1862, formed a pamphlet of 92 pages.

With the outbreak of the Civil War the appropriations ceased and this survey came also to an end.

SECOND SURVEY UNDER WILLIAM B. CLARK, 1896–1900.

From 1862 until 1896 no surveys at State expense were conducted in Maryland, although much good work was being done by the United States Geological Survey and members of the Maryland Academy of Sciences and the Johns Hopkins University.

In January of 1896 a bill for the reestablishment of the survey was introduced into the State assembly, which was finally passed, receiving the governor's signature on March 19. The following is the text of the bill:

An act to establish a State geological and economic survey, and to make provision for the preparation and publication of reports and maps to illustrate the natural resources of the State, together with the necessary investigations preparatory thereto.

SECTION 1. *Be it enacted by the General Assembly of Maryland*, That there is hereby established a State geological and economic survey, which shall be under the direction of a commission composed of the governor, the comptroller, the president of the Johns Hopkins University, and the president of the Maryland Agricultural College, who shall serve without compensation, but shall be reimbursed for actual expenses incurred in the performance of their official duties; and the said commissioners shall have general charge of the survey, and shall appoint as superintendent of the same a geologist of established reputation, and upon his nomination such assistants and employees as they may deem necessary; and they shall also determine the compensation of all persons employed by the survey, and may remove them at pleasure.

SEC. 2. *And be it enacted*, That the survey shall have for its objects:

(1) An examination of the geological formations of the State, with special reference to their economic products—viz, building stones, clays, ores, and other mineral substances.

(2) An examination and classification of the soils and a study of their adaptability to particular crops.

(3) An examination of the physical features of the State with reference to their practical bearing upon the occupations of the people.

(4) The preparation of special geological and economic maps to illustrate the resources of the State.

(5) The preparation of special reports, with necessary illustrations and maps, which shall embrace both a general and detailed description of the geology and natural resources of the State.

(6) The consideration of such other scientific and economic questions as in the judgment of the commissioners shall be deemed of value to the people of the State.

Sec. 3. *And be it enacted,* That the commissioners shall cause to be prepared a report to the legislature, before each meeting of the same, showing the progress and condition of the survey, together with such other information as they may deem necessary and useful or as the legislature may require.

Sec. 4. *And be it enacted,* That the regular and special reports of the survey, with proper illustrations and maps, shall be printed as the commissioners may direct, and that the reports shall be distributed or sold by the said commissioners as the interests of the State and of science demand, and all moneys obtained by the sale of the reports shall be paid into the state treasury.

Sec. 5. *And be it enacted,* That all material collected, after having served the purposes of the survey, shall be destributed by the commissioners to the educational institutions in such manner as to be of the greatest advantage to the educational interests of the State; or, if deemed advisable, the whole or a part of such material shall be put on permanent exhibition.

Sec. 6. *And be it enacted,* That the sum of $10,000 annually, or so much thereof as may be necessary, is hereby appropriated out of any funds of the treasury not otherwise appropriated, for the purpose of carrying out the provisions of this act.

Sec. 7. *And be it further enacted,* That this act shall take effect from the date of its passage.

At the call of the governor, the commission met upon March 25 in the executive chamber at Annapolis, all the members of the board being present. The meeting was organized by the election of President Gilman as temporary chairman. The following resolutions were then presented and adopted:

Resolved, 1. That the board proceed to the election of a president and a secretary and to the appointment of an executive officer, whose duty it shall be to advise with the geologist, supervise the outlays, and direct such measures as may best fulfill the requirements of the act establishing the survey.

2. That a substantial record book be procured, in which shall be entered all the actions both of the board and of the executive officer.

3. That a superintendent, to be known as State geologist, be chosen at once, whose duty it shall be to propose and, with the authority of the board, to carry out such measures as may be requisite for fulfilling the requirements of the act by which the survey is established.

4. That there shall be no salaried positions, but a moderate per diem allowance shall be made for work actually performed in the service of the survey.

5. That the board shall hold semiannual meetings, in the months of March and November, prior to and soon after the operations in the field, the meetings to be called by the governor, at such time and place as he may think best.

6. That it is the sense of the commission that the executive officer be empowered to make draft upon the controller from time to time for such money as the needs of the commission may demand, the amount to be drawn being limited by the appropriation for any one year.

7. That the executive officer be required to see that a detailed account of all expenses is kept and that the same be presented, with proper vouchers for approval, at each of the semiannual meetings of the commission, such vouchers being a part of their permanent records.

8. That the offer of the Johns Hopkins University to furnish, free of all charges whatsoever, suitable rooms for the offices of the survey and the use of its collections, maps, and apparatus be accepted, and that the headquarters of the survey, until otherwise ordered, be established at that place.

9. That the State geologist shall prepare and publish a series of occasional papers for the purpose of keeping the people of the State informed respecting the methods of the survey as it is in progress, and that the first of these reports shall be promptly issued to set forth the organization of the survey, and to show what has hitherto been done for the study of the geology, natural history, and resources of Maryland by public or private agencies.

10. That fuller reports upon special topics of importance to the State of Maryland shall be presented as soon as they can be prepared in a satisfactory manner, and that the State geologist be requested, if he finds it possible, to report in the first place upon building stones.

11. That the president of the board be requested to make known to the head of the United States Geological Survey in Washington and to the heads of the geological surveys in neighboring States the organization of the State Geological and Economic Survey of Maryland, and to ask their official cooperation.

12. That the State geologist be directed to make known, in the name of the board, that the cooperation of the transportation and express companies is particularly desired in furthering the work of the survey.

13. That this officer be also authorized to say, in the name of the board, that the friendly aid of the teachers in the higher educational institutions of the State and of other enlightened citizens will be appreciated by the board and gratefully acknowledged.

Administration.—The following permanent officers of the commission were nominated and elected—namely, Lloyd Lowndes, governor of Maryland, president; Daniel C. Gilman, president of the Johns Hopkins University, executive officer; R. W. Silvester, president of the Maryland Agricultural College, secretary. William Bullock Clark, professor of geology in the Johns Hopkins University, was chosen State geologist.

Subsequent acts extending the scope of the survey were passed in 1898. The following is a transcript of these acts:

An act to provide for the making of topographic maps and for the publication of reports of the State geological and economic survey, and to make an appropriation therefor.

SECTION 1. *Be it enacted by the General Assembly of Maryland*, That the commission established by the act of the general assembly of Maryland at the session of 1896, chapter 51, be, and the same is hereby, authorized to make provision for the completion of the topographic survey of Maryland in such manner as in the opinion of the commission will be of the greatest benefit to the agricultural, industrial, geological, and military requirements of the State of Maryland.

Sec. 2. *And be it further enacted*, That the said commission be, and the same is hereby, authorized to publish special reports with the various mineral products and with the natural resources of each county of the State of Maryland.

Sec. 3. And for the purpose of carrying out the provisions of this act be it further enacted that the sum of $5,000 annually, in addition to the amount appropriated by the act of the general assembly of Maryland at the session of 1896, chapter 51, or so much thereof as may be necessary, be, and the same is hereby, appropriated, out of any funds in the treasury not otherwise appropriated, and the said amount be drawn from the treasury by the said commission in the same manner as the other funds of the survey.

Sec. 4. *And be it further enacted*, That this act shall take effect from the date of its passage.

Above bill introduced in the senate February 2, passed by that body February 16, by the house March 17, and signed by the governor April 2, 1898.

An act to confer additional powers upon the commission established by the act of the general assembly at the session of 1896, chapter 51, by providing for the investigation of the question of road construction in this State, and for the preparation of reports thereon, and to make an appropriation therefor.

Section 1. *Be it enacted by the General Assembly of Maryland*, That the commission established by the act of the general assembly, at the session of 1896, chapter 51, be, and the same is hereby, authorized to make provision for the investigation of the question of road construction in Maryland.

Sec. 2. *And be it enacted*, That the said commission be, and the same is hereby, authorized to appoint, under the direction of the superintendent of the survey, such assistants and other employees as they shall deem necessary, and the said commission shall also determine the compensation of all persons employed, and may remove them at pleasure.

Sec. 3. *And be it enacted*, That the said commission shall see that proper investigation is made of the condition of the roads in this State, and of the best means of improving the same, together with a study of the classification and distribution of the road-building materials in the several counties.

Sec. 4. *And be it enacted*, That the said commission shall see that a report upon the state of the roads and the best method of improving, constructing, and maintaining the same, with estimates of costs, expenses, and plans, be submitted at the next session of the legislature, and that special reports be prepared at such times as they are deemed necessary.

Sec. 5. *And be it enacted*, That the said commission shall see that record is kept of all its proceedings, and of all the moneys received and spent under its direction, and for what purposes; which record and account shall be submitted to the said commission at the semiannual meetings of the same, to take place in March and November, such records and accounts to be always open to the inspection of any committee which the legislature may appoint.

Sec. 6. *And be it enacted*, That all moneys paid out on account of this work shall be paid by the State treasurer upon the order of the executive officer of the commission, endorsed by the comptroller.

EDWARD HITCHCOCK

STATE GEOLOGIST OF MASSACHUSETTS, 1830-33 AND 1840-44;
STATE GEOLOGIST OF VERMONT, 1857-60.

SEC. 7. *And be it enacted*, That the sum of $10,000 annually, or so much thereof as may be necessary, be, and the same is hereby, appropriated out of any money in the treasury not otherwise appropriated, for the purpose of carrying out the provisions of this act.

SEC. 8. *And be it further enacted*, That this act shall take effect upon the date of its passage.

Above bill passed the house April 1; by the senate April 4; signed by the governor April 9, 1898.

The organization was still in existence at the time this Bulletin went to press.

MASSACHUSETTS.

SURVEYS UNDER EDWARD HITCHCOCK, 1831–1841.

Organization.—To Massachusetts belongs the credit of having inaugurated and carried to successful completion under State auspices, the first geological and natural history survey on the Western Continent. The causes which led up to this are not at present easily ascertainable, but in Governor Lincoln's message to the legislature, May 29, 1830, occurs the following paragraph:

> I beg leave to suggest to your consideration the utility of connecting with the geographical surveys, an examination of the geological features of the State, with a view to the exhibition of them on the map. Much knowledge of the natural history of the country would thus be gained, and especially the presence of valuable ores, with the localities and extent of quarries, and of coal and lime formations, objects of inquiry so essential to internal improvements, and the advancement of domestic prosperity, would be discovered, and the possession and advantages of them given to the public. I am assured that much has already been gratuitously done, by some eminent professors in our colleges, towards the accomplishment of such a work, and that, at a little expense, it might be completed, and the fruits of their generous labors thus far, be secured to the State. This, however, will require the interposition of your authority in increasing the present appropriaton, and permitting an application of it, so far as may be necessary, in the exercise of a sound discretion, to the end proposed.

In accordance with this suggestion there was passed the following resolve:

Resolve authorizing further appropriations for a survey of the Commonwealth. June 5, 1830.

Resolved, That his excellency the governor, by and with the advice of the council, be, and he is hereby, authorized to appoint some suitable person to make a geological examination of the Commonwealth, in connection with the general survey,[1] in order that the same may be inserted on the map which may be published, and he is authorized to apply such portion of the sum herewith appropriated, not exceeding $1,000, as may be necessary for the accomplishment of this object.

Additional acts relating to the conduct of the survey and the publication of its reports were subsequently passed, as follows:

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[1] A general trigonometric survey authorized by resolve of Mar. 3, 1830.

Resolve in relation to the geological survey of the Commonwealth. February 2, 1831.

Resolved, That his excellency the governor, by and with the advice and consent of council, be, and he is hereby, authorized to direct the person who is appointed to make a geographical survey of the Commonwealth, to cause to be annexed to his report on that subject a list of the native mineralogical, botanical, and zoological productions of the Commonwealth, so far as it may be practicable to ascertain the same, within the limits of the appropriation already made for this survey.

Resolved, That his excellency the governor, by and with the advice and consent of the council, be, and he is hereby, authorized to cause the said geological report, provided the same should be made before the general survey of the Commonwealth shall be completed, to be published in such way and manner as he with the advice of the council may deem proper and expedient; and he is authorized to draw his warrant upon the treasurer of the Commonwealth for such sum or sums, not exceeding $100, as may be necessary to carry this resolve into full effect.

Resolve making further appropriations for a survey and geological examination of the Commonwealth. June 22, 1831.

Resolved, That his excellency the governor, with the advice of the council, be, and he is hereby, authorized to draw his warrant, from time to time, upon the treasurer of the Commonwealth, for any sum or sums, not exceeding $3,000, in addition to the sums heretofore appropriated, which may be necessary to carry more fully into effect the resolves authorizing the appointment of a surveyor to make a general survey of the Commonwealth, passed on the 3d day of March, A. D. 1830,[1] and the resolves in addition thereto, and further authorizing the appointment of a suitable person to make a geological examination of the Commonwealth, passed on the 5th day of June, A. D. 1830.

Resolve for the distribution of the first part of the Report on the Geological Survey of the Commonwealth. March 24, 1832.

Resolved, That the 600 copies of the first part of the Report of the Geological Survey of the Commonwealth, provided in pursuance of an arrangement made by his excellency the governor, with advice of council, for the use of the government, be delivered to the secretary of the Commonwealth, and by him be distributed as follows, viz: Four copies to the governor; two copies to the lieutenant governor; one copy to each member of the council; one copy to each member of the senate and house of representatives; five copies to be deposited in the library of the State; and that the remaining copies be distributed as his excellency the governor may direct.

Resolve for the publication and distribution of the Report on the Geological Survey of the Commonwealth. March 2, 1833.

Resolved, That his excellency the governor be, and hereby is, authorized to cause 1,200 copies of the report on the geological survey of the Commonwealth, including that part of the report already made, as well as the part hereafter to be made, with the drawings which shall accompany said report, to be published in such way and manner as he shall deem proper and expedient; and he is authorized, with the advice and consent of council, to draw his warrant upon the treasurer of the Commonwealth for such sum or sums as may be necessary to carry this resolve into full effect.

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[1] This resolution authorized a general survey of the Commonwealth for the purpose of preparing "an accurate skeleton plan of the State which shall exhibit the external lines thereof and the most prominent objects within those lines and their locations." Geology was not mentioned.

Resolved, That the said 1,200 copies, when published, be delivered to the secretary of the Commonwealth, to be distributed in the following manner, viz: Twelve copies to the governor; six copies to the lieutenant governor; one copy to each member of the council, senate, and house of representatives; one copy each to the secretary, treasurer, and to each of the clerks and chaplains of the two houses; one copy to each town in the Commonwealth; five copies to be deposited in the library of the State; two copies each to Harvard, Amherst, and Williams Colleges; one copy each to the Theological Seminaries at Andover and Newton; one copy to each incorporated academy in the Commonwealth; one copy each to the Boston and Salem athenaeums; one copy to the American Academy of Arts and Sciences; one copy to the Antiquarian Society at Worcester; one copy to the Massachusetts Historical Society; one copy to the Boston Society of Natural History; twenty copies to the geological surveyor, and one copy to each person who shall have aided him in preparing the catalogues appended to the report; two copies to the Library of the United States; one copy to the executive of each State in the Union; and the remaining copies to be disposed of in such manner as his excellency the governor shall direct.

Resolve making a further appropriation for the survey of the Commonwealth. March 25, 1833.

Resolved, That his excellency the governor, with the advice and consent of the council, be, and he is hereby, authorized to draw his warrant from time to time upon the treasurer of the Commonwealth, not exceeding $8,200, in addition to the sums heretofore appropriated, which may be necessary to carry more fully into effect the resolve authorizing a general survey of the Commonwealth, passed on the 3d day of March, A. D. 1830, and the resolves in addition thereto; and he is further authorized to apply such portion of the above-named sum, not exceeding $300, as may be necessary for completing the geological examination of the Commonwealth provided for by a resolve passed on the 5th day of June, A. D. 1830.

On the 19th of February, 1834, the following resolution was adopted by the legislature:

Resolved, that his excellency the governor, with the advice of the council, be authorized to cause to be printed, under the superintendence of the geological surveyor, a new edition of Professor Hitchcock's Report on the Geology of this Commonwealth, and the atlas accompanying it, with such alterations and additions as may be proposed by the professor and approved by the executive; and that a warrant be drawn on the treasury for such sum as may be necessary to defray the expenses thereof: *Provided*, That the whole expenditure shall not exceed the sum of $2.60 for each copy.

Resolved, That the said 500 copies, when published, shall be delivered to the secretary of the Commonwealth, and be distributed in the following manner, viz: Twelve copies to the governor; 10 copies to the surveyor; one copy to each of the chaplains of the senate and house of representatives; one copy to each incorporated lyceum and athenaeum in this Commonwealth; two copies each to the Berkshire Medical Institution and the Massachusetts Medical College; one copy to each member of the council, senate, and house of representatives, who was not a member of either of those branches of the government for the last year; one copy to each of the permanent clerks in the office of the secretary of state, treasurer, and adjutant general; two copies to the Pilgrim Society at Plymouth; and the remaining copies to be disposed of in such manner as the legislature may direct.

Administration.—In accordance with the resolution of 1830, Governor Lincoln issued, on June 25 of that year, a commission to Prof. Edward Hitchcock, of Amherst College, directing him to make a survey of the Commonwealth in a manner contemplated by the resolution and to perform such other duties relating thereto as might be enjoined upon him and obeying such instructions, from time to time, as he might receive from the proper authority.

Professor Hitchcock seems to have entered promptly upon the work and submitted his first report (pt. 1, Economical Geology) under date of January 1, 1832. This was a pamphlet of 70 pages, in which was outlined his general plan of work, as well as the preliminary report on the economic geology of the State. He announced his purpose to divide his final report into four parts, the first the economical portion already mentioned; the second, topographical geology, or an account of the most interesting features of the scenery; third, scientific geology, or an account of the rocks in their relation to science; and, fourth, catalogues of native minerals, botanical and zoological productions of the Commonwealth, this latter being agreeable to the resolution of February 2, 1831.

Realizing that a considerable period must elapse before the preliminary report on economic geology could be completed, Doctor Hitchcock announced the construction of a small map from such materials as already existed, upon which he delineated the various kinds of rocks that he found prevailing in the State, the same being shown by different colors and simple markings. To avoid confusion he placed on this map such topography and geography as was absolutely necessary, and employed but six colors for the rocks, although announcing that more than 20 kinds were represented, his object being "to simplify the map as to render it easily intelligible, while it exhibits all that is important to the practical man as well as to the scientific inquirer."

So far as can be gleaned from available records no paid assistants were employed in the strictly geological work, nor are there any statements regarding the salaries.

In the biological divisions of the survey, Hitchcock was assisted by an able corps of specialists, including T. W. Harris on mammalia and insects, Ebenezer Emmons on birds, S. C. H. Smith on reptiles, J. V. C. Smith on fishes, T. A. Greene on marine shells, T. M. Earle on land and fresh-water shells, A. A. Gould on crustacea, N. M. Hentz on spiders, and others.

In accordance with directions received from the governor, but which were not incorporated in the original resolution, there was made a collection of rocks and minerals, comprising some 1,550 specimens, which were installed in the rooms of the Boston Society of Natural History. Three collections of 900 specimens each were reported as made for the three colleges in the State. Concerning this collection, Professor Hitchcock wrote in his first report (1832):

> To illustrate the first and third parts of the report I have, in accordance with directions from your excellency, collected specimens of every variety of rock I could find in the Commonwealth; and in all cases where a rock is quarried or might be quarried in several places I have endeavored to obtain specimens from each locality. I have collected likewise all the ores of importance found in the State, as well as the other simple minerals which could be obtained without much difficulty or delay. I did not suppose that my instructions authorized me to be at much expense and trouble in procuring every rare mineral that has been described as occurring in the State; although this object may still be accomplished, if I have mistaken the intentions of the government. The collection of specimens which I have already made for the use of the government contains 780 individual pieces, and it is not yet completed; so that I shall not be able to forward it with this part of my report. I do not know to what use the government intends to devote this collection, but, supposing it should be placed in some public situation, in order to exhibit to the citizens the geology and mineralogy of the State, I have endeavored to obtain from all the more important quarries and beds whence stones are obtained for the purpose of architecture or ornament, specimens which would fairly exhibit the qualities and value of each.

Expenses.—The entire expense of this survey, as announced in the second edition of his report (1835), including the preparation of the report, collecting, labeling, and arranging the 1,550 specimens of rocks and minerals, and the 900 specimens for each of the colleges of the State, was $2,030. This sum does not include the cost of printing the several editions of the reports.

Publications.—Of the first report on economic geology printed, 600 copies were issued in 1832, and in 1833 the complete report, comprising economic, topographic, and scientific geology, as well as the list of animals and plants, compiled in accordance with the act of February 2, 1831, and forming altogether a large octavo volume of 700 pages, was issued. This was accompanied by an atlas containing a geological map and 18 plates of scenery, fossils, and sections. Twelve hundred copies were printed and distributed, in accordance with the act of March 2, 1833. In 1835 a second edition of this report was issued in conformity with the resolution of the legislature, bearing date of February 19, 1834. Five hundred copies were printed, the cost of same being limited by law to $2.60 a copy. This differed but slightly from the first edition. The most important and extensive changes, as noted in the letter of transmission, were included in the catalogue of animals and plants embraced in part 4. These were nearly all rewritten and several of them nearly doubled in extent.

SURVEY OF 1837.

In 1837 the subject of a renewal of the survey came before the legislature, and a resolution was passed authorizing the governor and council to appoint some suitable person to make a further and thorough geological and mineralogical, botanical, and zoological survey of the Commonwealth, with particular reference to the discovery of coal, marl, and ores, and an analysis of the various soils of the State relative to agricultural benefit. The following is the text of this and subsequent acts relating thereto:

Resolution providing for an agricultural survey of the State.

Resolved, That his excellency the governor, by and with the advice of the council, is hereby authorized and requested to appoint some suitable and competent person, whose duty it shall be, under the direction of his excellency the governor, to make an agricultural survey of the Commonwealth, collect accurate information of the state and condition of its agriculture, and every subject connected with it; point out the mines of importance, and make a detailed report thereof with such exactness as circumstances will admit.

Resolved, That a summary of such survey and examination shall be furnished to his excellency the governor every six months until the whole shall be completed, and at such other times as shall be required, to be published in such way and manner as he, with the advice of the council, shall deem to be expedient and useful; and he is authorized to draw his warrants, from time to time, upon the treasurer for such sums as may be necessary to defray the expenses of said survey and to enable the person so appointed to proceed in the execution of the duties that shall be required of him; and to pay the same to him, not exceeding the sum of $2,500 per annum.

April 12, 1837.

This resolution was in due season followed by two others relative to the publication and distribution of the reports and to the final abandonment of the survey. These were as follows:

Resolved, That the governor is hereby authorized to procure the publication of 1,500 copies of the reports which he has received, or may hereafter receive, under resolve of the 12th of April, in the year 1837, providing for a further geological, mineralogical, botanical, and zoological survey of the Commonwealth; and to draw his warrant, with the advice and consent of the council, upon the treasurer of the Commonwealth for such sums as may be necessary for that purpose.

Resolved, That the said copies, when published, be delivered to the secretary of the Commonwealth, to be distributed in the following manner: Twelve copies to the governor; six copies to the lieutenant governor; one copy to each member of the council, senate, and house of representatives; one copy each to the secretary, treasurer, and to each clerk and chaplain of the two houses; one copy to the secretary and one to each of the board of education; 20 copies to the geological surveyor; and 10 copies to each commissioner appointed under the resolve of April 12, 1837; five copies to be deposited in the library of the State; one copy to each town in the Commonwealth; two copies each to Harvard, Amherst, and Williams Colleges; one copy each to the theological seminaries of Andover and Newton; one copy to each incorporated athenaeum, lyceum, and academy in the Commonwealth; one copy to the American Academy of Arts and Sciences; one copy to the Antiquarian Society at Worcester and one to the Pilgrim Society at Plymouth; one copy to the Massachusetts Historical Society, and to every other incorporated historical society in the Commonwealth; one copy to the State lunatic hospital at Worcester; one copy to the Boston Society of Natural History; one copy to the Essex County Natural History Society; one copy each to the Massachusetts and Salem Charitable Mechanic Associations; one copy to the library of the East India Marine Society in Salem; two copies to the Library of the United States; one copy to the executive of each State in the Union; 100 copies to be placed at the disposal of the governor; and the remainder to be subject to the further order of the legislature.

April 9, 1839.

A resolution concerning the agricultural survey of the State.

Resolved, That from and after the 25th day of May next, the resolve passed the 12th day of April, in the year 1837, providing for an agricultural survey of the Commonwealth, be repealed.

Approved by the governor, February 15, 1841.

Administration.—In accordance with the act of April 12, 1837, Professor Hitchcock again took up the direction of the geological survey and on April 1 of the year following rendered a report of 139 pages on the economical part of the work. This was printed without special order. The work contained a large number of physical and chemical analyses of soils, with a discussion of the method of procedure and the agricultural value of the results.

The biological section of the survey was less prompt in making its returns. The commission, as stated in the introduction to the reports, was established on June 10, 1837, and had received the following instructions:

> It is presumed to have been a leading object of the legislature in authorizing the survey to promote the agricultural benefit of the Commonwealth, and you will keep carefully in view the economical relations of every subject of your inquiry. By this, however, it is not intended that scientific order, method or comprehension should be departed from. At the same time, that which is practically useful will receive a proportionally greater share of attention than that which is merely curious: the promotion of comfort and happiness being the great end of all science.

In the division of work as finally adopted Chester Dewey, professor of botany, materia medica, etc., in the Berkshire Medical Institution, reported upon the herbaceous plants; George B. Emerson, president of the Boston Society of Natural History, upon the trees and other ligneous plants; Ebenezer Emmons, professor of natural history in Williams College, upon the mammalia; A. A. Gould, one of the curators in the Boston Society of Natural History, upon the miscellaneous crustacea and radiata: T. W. Harris, librarian of Harvard University, upon the insects injurious to vegetation; Rev. William B. O. Peabody, of Springfield, upon the birds; and D. H. Storer upon the fishes.

It was agreed that "instead of confining themselves to completing the catalogues in the several departments as issued by the first survey, each commissioner should endeavor, as far as possible, to study and describe every new object which should present itself in his own department, and, where the descriptions already given were incomplete or unsatisfactory, or contained in books not of easy access to the public, to redescribe or make additions or changes such as should seem best."

It became at once evident that satisfactory final reports could not be issued within the limits of a single year. Partial reports were therefore made by each of the commissioners, which, with a letter from the chairman, were ordered printed and leave was asked and obtained to defer their report for another year. The final reports as issued under date of 1840 were monographic in character, and several of them have since been reprinted as separate documents: Gould's report on Invertebrate Animals, formed a work of 373 pages and 14 plates; Harris's Insects Injurious to Vegetation, the first issue of which was made under date of 1840 and reprinted under date of 1862, formed a volume of 640 pages; Dewey's report on Herbaceous Plants formed a work of 277 pages; Emmons on Quadrupeds, 86 pages; Storer on Fishes and Reptiles, 235 pages; Peabody on Birds, 147 pages.

It may be well to note here that Professor Hitchcock's reports on the fossil footprints of the Connecticut Valley, entitled Ichnology of New England, were printed by the State, in accordance with resolutions approved March 29, 1857, and March 26, 1858. The work of preparation appears, however, to have been done wholly under private auspices.

In December, 1839, the final report of the geological division of the survey was presented and printed under date of 1841 in the form of two quarto volumes of 831 pages, all told, including 51 full-page plates and maps. Fifteen hundred copies were issued and distributed in accordance with the act of April 9, 1839.

By resolution of February 15, 1841, the original resolution providing for an agricultural survey of the Commonwealth was repealed as previously mentioned.

Expenses.—Twenty-five hundred dollars was appropriated for the carrying out of this survey. Data are not available to show the amount actually expended. It is stated, however,[1] that each member of the biological corps received the sum of $350 for his services.

Benefits.—As above noted, Massachusetts was the first State to begin and carry to completion a geological and natural history survey at the public expense. The benefits can not be calculated in terms of money. From both State and national standpoints these may well be considered invaluable. The example set was speedily followed, and by 1840, or between the time of the beginning and conclusion of the Massachusetts survey, 18 other States of the Union had commenced similar investigations.

SURVEY OF PUBLIC LANDS OF MAINE AND MASSACHUSETTS UNDER C. T. JACKSON, 1837–1838.

As already noted (see under Maine, p. 129), Massachusetts undertook, with Maine, a joint survey of the public lands in 1836. The following is the text of the law:

Resolve of the Legislature of Massachusetts.

Resolved, That the governor, with advice of the council, be hereby authorized to employ some suitable person or persons to make a geological survey of any lands in Maine where such survey, together with the various observations which the surveyors will have opportunity to make, will probably lead to a more accurate knowledge of the worth of the public domain.

Resolved, That the governor and council may, if they deem it expedent, advise and cooperate with the government of the State of Maine in relation to such survey.

Resolved, That his excellency the governor may draw his warrant for whatever expense shall be incurred in the accomplishment of the survey recommended in the two preceding resolutions.

Passed March 21, 1836.

Under this act Dr. C. T. Jackson received the appointment and made two reports, dated 1837 and 1838. (See under Maine.)

In 1874, in response to a memorial from the American Academy of Arts and Sciences urging "a new and thorough scientific survey of the Commonwealth," the legislature referred the question to the board of education with a request that they "consider the same and report thereon at the next general court." The board of education in its turn appointed Gardner G. Hubbard, Rev. A. A. Miner, and Rev. Philips Brooks a subcommittee to investigate and report. The subcommittee entered fully into a consideration and rendered a comprehensive report on December 1, 1874, which was printed in the form of House Document No. 40 of that year. It appears that opinions were obtained from nearly every scientific man of importance within the State limits, and the advisability of topographical, hydrographical, geological, and biological surveys fully considered. It was estimated that the survey as outlined would require an appropriation of $385,000, which could be made payable in 15 installments of $25,666 each. Although the reports of the committee and opinions expressed by those consulted appear to have been almost uniformly favorable, yet no definite action toward the establishment of the survey seems to have been taken, nor had a State survey been reestablished up to 1900.[1]

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[1] House Document No. 40, 1875.

MICHIGAN.

FIRST GEOLOGICAL SURVEY UNDER DOUGLASS HOUGHTON, 1837–1842.[2]

The importance of a geological survey of the State of Michigan became early apparent through the work of Schoolcraft and others, particularly in the copper regions adjacent to Lake Superior, but the most powerful and perhaps the deciding motive for the establishment of such was the urgent need of finding larger and cheaper supplies of salt than could be furnished from sources beyond the State limits.

Organization.—Michigan was admitted to the Union on January 26, 1837, and on the 23d of February following an act was signed by Gov. S. T. Mason providing for a geological survey of the State. The following is the text of this act:

An act to provide for a geological survey of the State.

SECTION 1. *Be it enacted by the Senate and House of Representatives of the State of Michigan,* That the governor is hereby authorized and directed to nominate, and by and with the advice and consent of the senate, to appoint a competent person, whose duty it shall be to make an accurate and complete geological survey of this State, which shall be accompanied with proper maps and diagrams, and furnish a full and scientific description of its rocks, soils, minerals, and of its botanical and geological productions, together with specimens of the same; which maps, diagrams, and specimens shall be deposited in the State library, and similar specimens shall be deposited in such literary and scientific institutions as the governor shall direct; and the governor is further authorized to appoint, from time to time, as the exigencies of the case may require, competent persons to act as assistants under the direction of the geologist.

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[1] By an act approved June 3, 1903, a second survey was begun, with William N. Rice, director. See Bull. 465, U. S. Geological Survey, 1911.

[2] Condensed from manuscript by Dr. Alexander Winchell. The portion of this manuscript relating to Prof. Winchell's own work and that of Houghton is remarkably full and detailed, and may seem to give undue prominence to the Michigan survey. Inasmuch, however, as it was prepared by one thoroughly acquainted with all the details, and himself a participant in the work, and inasmuch, further, as Houghton's reports are out of print and quite inaccessible to most students, it has seemed advisable to print it as written and in almost its entirety, cutting out only occasional personal and perhaps pointed references to certain individuals.

SEC. 2. A sum not exceeding $3,000 for the year 1837, a sum not exceeding $6,000 for the year 1838, a sum not exceeding $8,000 for the year 1839, and a sum not exceeding $12,000 for the year 1840, is hereby appropriated to defray the expenses that may be incurred under this act, which sums shall be paid out of the treasury from any money not otherwise appropriated, at such times and in such sums as the governor may direct; and an account of all the expenditures of each year shall be annually reported to the legislature.

SEC. 3. The geologist appointed under the provisions of this act shall make a report annually to the legislature, on the first Monday of January, in each year, setting forth generally the progress made in the survey hereby authorized.

Approved February 23, 1837.

Subsequently the following were passed:

An act making an appropriation for the improvement of the State salt springs.

SECTION 1. *Be it enacted by the Senate and House of Representatives of the State of Michigan,* That the sum of $1,500 be, and the same is hereby, appropriated out of any moneys in the treasury, or that may hereafter come into the treasury, to the credit of the internal improvement fund, not otherwise appropriated, for the purpose of continuing the process of sinking tubes and boring at the State salt springs at Grand River, in Kent County, and also on the Tittabawassee River, in Midland County.

SEC. 2. That the State geologist be directed to contract for the boring to be done at each of said salt springs, and also to contract for the performance of all other work connected therewith, so far as in his opinion the same can be advantageously done.

SEC. 3. All moneys drawn under this act shall be paid by the State treasurer on the warrant of the auditor general, which warrant shall only be issued upon the certified estimate of the State geologist, except such sums as may be necessary for contingent expenses or in payment for such works as it may not be deemed advisable to do by contract, which sums shall be paid directly to the State geologist, and for which he shall deposit with the auditor general proper vouchers at the time of receiving his warrant therefor.

SEC. 4. On all contracts for work in progress a sum amounting to not less than 15 per cent upon the work completed shall remain unpaid until the final completion of the contract.

SEC. 5. This act shall take effect and be in force, from and after its passage.

Approved February 1, 1842.

An act making appropriations for the current expenses of the Government for the year 1842.

For the salary of State geologist, $1,000; for the salary of State topographer, $800; for the contingent expenses for the completion of the geological survey of the State, a sum not exceeding $400.

SEC. 2. The salaries above specified shall be payable quarterly, commencing at the date of the respective appointments of the incumbents, or at the same rates for fractional quarters.

Approved February 17, 1842.

Administration and procedure.—Under these acts Dr. Douglass Houghton, of Detroit, was appointed State geologist, and Dr. Abram Sager, also of Detroit, zoological and botanical assistant. The geological interest most conspicuous in importance at that time was salt. Doctor Houghton had already visited the shores of the Upper Peninsula in company with Henry R. Schoolscraft, and must have remarked the indications of mineral wealth in that remote region; but the salt springs of the Lower Peninsula were better known and more accessible. They had been noticed from the earliest settlement of the territory, and the General Government had made numerous reservations of salt spring lands. In the act of June 23, 1836, 72 sections of these lands were patented to the State.

FIRST YEAR OF THE SURVEY, 1837.

The general impression prevailed in Michigan that salt was destined to become an important resource. The State geologist accordingly devoted his first efforts to a general study of the facts within reach of ready observation. His first report, of 39 pages,[1] was dated January 22, 1838, and devoted 21 pages to this subject.

He found the salines of the State distributed in five groups: 1. Those upon the Grand River, near Grand Rapids. 2. Those on Maple River, in Gratiot County. 3. Those on the Tittabawassee, in Midland County. 4. Those of Macomb County. 5. Those on the Saline River in Washtenaw County. It was impossible as yet to know that these groups of springs were supplied from formations of three different ages. As saline indications of importance were known south of a line drawn from Monroe to Grand Rapids, Doctor Houghton gave analyses of 20 samples of brine from as many different localities within the peninsula. These were generally located on marshes, circumstanced similarly to the salines of New York, or on the immediate banks of streams subject more or less to overflow. The strongest of yield was from 150 to 400 grains of sodium chloride in 100 cubic inches of brine. As the result of the observations this year, Doctor Houghton advanced the opinion that the brine supplied at the surface at any of the localities examined would prove too weak and too limited in quantity to justify the expectation of remunerative manufacture. At the same time he announced "a general resemblance between the geology of the valley of the Ohio and that of Michigan," and stated his belief that "the rock formations (presumably the surface rocks) of our saliferous district are somewhat lower in the series than those occurring in the principal salines on the Ohio;" and from this "inferred that the salt-bearing rock would be nearer the surface here" than in Ohio. The similarity of circumstances, as he erroneously conceived, attending the occurrence of brine springs in Michigan and Ohio, led him to advance the opinion that in this State, as well as Ohio, success might follow the "sinking of shafts through the rock strata" in the vicinity of the salines. He adds:

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[1] House Documents, 1838, pp. 276–316.

> I do not hesitate to give it as my opinion, drawn from a careful examination of the subject, that points may be selected where these operations may be conducted with the strongest prospects of eventual success.

The general geology of the Lower Peninsula is treated in the first report, under the following subdivisions:

1. The Upper Sandstone of the Peninsula: He here embraces the sandstones exposed in the counties of Hillsdale, Jackson, Calhoun, Kalamazoo, Livingston, Ingham, Eaton, Barry, Shiawassee, Clinton, and the eastern part of Ionia. A large number of outcrops are enumerated. It is evident now that the localities mentioned belong to three different ages.

2. Gray limestone: This he regards "without doubt, identical with the mountain limestone of European geologists." Numerous outcrops are described, but these embrace localities of the Corniferous limestone, the lower Carboniferous limestone on the Charity Islands, and coal measure limestones in Shiawassee and Midland counties.

3. Lower Sandstone or graywacke group: Here are included the sandstones of Point aux Barques and the red sandstone of Lake Superior, which he thinks "may be referred to the lower portion of this group."

4. Coal, the existence of which is distinctly announced.

5. Gypsum: This, he says, is apparently of considerable extent in Kent County.

6. Clay.

7. Sand.

8. Marl.

9. Bog iron ore.

10. Mineral springs: Several highly sulphurated springs occur in Monroe, "and the waters being also charged with carbonate of lime, give rise to considerably elevated mounds of calcareous tufa." He mentions the remarkable spring in a marsh in the town of Havre, Monroe County, which has a circumference of 150 feet and a depth of 35 feet. He alludes to the great physical difficulties encountered, the sparseness of the population, and consequent lack of local information; and says that the appropriation has not been enough "to cover even the traveling expenses of those engaged in these arduous duties."

The geological corps consisted of Douglass Houghton, geologist; Abram Sager, principal assistant in charge of botanical and zoological departments; S. W. Higgins, topographer and draftsman; Columbus C. Douglass, subassistant; Bela Hubbard, subassistant; William P. Smith, subassistant in charge of mechanical zoology.

An appendix embraces a large number of questions addressed to proprietors of lands, answers to which are desired by the survey.

SECOND YEAR OF THE SURVEY, 1838.

This report, presented to the legislature of 1838, led to the passage of an act, approved March 24, 1838, "To provide for the improvement of certain State salt springs," directing the State geologist to proceed to make explorations by boring at one or more of the springs, and appropriating $3,000 to defray expenses. This legislature also revised the organization of the survey and enlarged its resources. By an act approved March 23, 1838, the former law was repealed and a new organization provided which should consist of four departments: 1, Geological and mineralogical; 2, zoological; 3, botanical; 4, topographical. Each department was to have its head and carry on independent work; but all the others were to report to the chief geologist. "Minor assistants" were also provided in the several departments. Of the specimens collected one series was to belong to the State, and 16 other series, if possible, were to be placed in the hands of the board of regents to be distributed to the university and its branches; but the university was to pay $4,000 to the State before receiving the benefit of this act. The appropriation was $12,000 for each year between March 1, 1838, and March 1, 1844. The State geologist was to receive for salary, $2,000; the zoologist, $1,500; the botanist, $1,500; the topographer, $1,000. Each minor assistant was to be paid $800, but the chief assistant of the zoologist, $1,000. For contingent expenses a balance of $2,000 remained.

Under this organization the following appointments were made: Douglass Houghton, State geologist; Abram Sager, zoologist; John Wright, botanist; Sylvester W. Higgins, topographer; Columbus C. Douglass, Bela Hubbard, geological assistants.

It appears that the "practical" instincts of a certain portion of the legislature began already to inquire *cui bono?* A resolution was passed calling upon the State geologist "for information as to the direct benefits which may be anticipated to the agricultural interests of the State from the completion of the geological survey." To this Doctor Houghton replied, under date of March 2, 1839, grouping the "direct benefits" under five heads: 1. In disseminating knowledge of the soils. 2. In showing how to correct deficiencies. 3. In bringing to light mineral manures. 4. In accumulating information about destructive insects. 5. In disseminating a knowledge of plants, both the useful and the noxious.

The results of the field work of 1838 may here be summarized: On the 1st of January, 1839, the State geologist communicated a special report on the State salt springs, in which he announced that he had visited the various salines of Pennsylvania, Virginia, and Ohio with the view of collecting information to guide his procedure and had commenced the sinking of two shafts—one on the Tittabawassee, near the mouth of Salt River, and the other on the Grand River, about 3 miles west of Grand Rapids. The springs affording the strongest brines were located in these districts. The work, however, was beset with difficulties very great even for that period, and had made but little progress. On the Tittabawassee the surface materials were first penetrated by a shaft 45 feet deep, when fresh and brackish waters overpowered the pumps, and an attempt was made to sink a drill at a neighboring point. The well near Grand Rapids (Sec. 3, T. 6, N. 12 W.) was begun in July, 1838, but had made unsatisfactory progress.

To complete the history of these two wells in this connection it may be said that $15,000 was appropriated on January 28, 1839, for the continuance of the work, and $5,000 for each of the wells on March 31, 1840, $300 on April 12, 1841, to pay certain expenses connected with them, and $15,000 on February 1, 1842, "from the internal improvement fund," to still maintain the exploration. As a result, the drill on the Tittabawassee well, from May to November, 1841, penetrated but 139 feet, when a rock was struck (supposed by Doctor Houghton to be quartzite), which the drill entered but half an inch in 11 hours, though loaded with a weight of 270 pounds. At this obstacle the work was suspended, and by act of February 15, 1842, the well was abandoned. The well on the Grand River was prosecuted till 1842, when work was suspended at a depth of 473 feet.[1]

Subsequently, as appears from Doctor Houghton's report on the State salt springs, dated January 23, 1843, he delegated the direction of the work to Hon. Lucius Lyon, who carried the boring to the depth of 876 feet. The discharge of brackish water was over 200 gallons a minute. At a little greater depth, according to the writer's private information, the drill "got jammed" and the work was given up.

In these two costly and protracted experiments no brine was obtained materially better than that previously occurring on the surface. In the light of present knowledge the geological conditions of these failures are perfectly intelligible.

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[1] Had the Tittabawassee well been drilled to a corresponding depth, it is probable that success would have crowned Doctor Houghton's indefatigable efforts, and the manufacture of salt would have been begun 20 years earlier than it was.

It may be added that the State now took the requisite steps to bring the salt spring lands into market on the same terms as ordinary lands. Twenty-five sections were assigned March 28, 1849, for an endowment of the normal school at the minimum price of $4 an acre for the unimproved tracts, and 22 sections were set apart February 12, 1855, for the endowment of an agricultural college.

As an individual enterprise another well was begun in January, 1840, by Lucius Lyon near Bridge Street bridge in the present city of Grand Rapids and by July, 1841, it had penetrated to the depth of 661 feet. It furnished a flow of one hogshead a minute of brackish water, which, when isolated from the influx of fresh water, was found one-fifth saturated, "or at least equal in strength to brine at that time used on the Kanawha and Ohio Rivers." With salt selling at $3 a barrel, Mr. Lyon was enabled to manufacture a limited amount without loss. The want of brine of adequate strength, however, led to an early suspension of the business. Thus ended the first period of salt enterprise in Michigan.

Recurring now to the results of geological field work in 1838, the second year of the survey, we look into the report of the State geologist, dated February 4, 1839. We find that Doctor Houghton's personal labors were restricted "to an examination of the coast of those portions of our State bordering on Lakes Huron and Michigan," with some limited portions of the interior and the southern counties. In a sketch of the topography of the northen part of the Peninsula he refers to a range of hills a little south of Thunder Bay River which "stretch in a southwesterly direction toward the head of Lake Michigan. This range at its commencement," he continues, "is usually known as the highlands of the Au Sable. These hills follow the line of bearing of the rock formation, and no doubt, extend diagonally across the State, forming a portion of the summit of the more northern part of the Peninsula" (pp. 6, 7). This citation from one of Doctor Houghton's earliest records reveals a prepossession which gave bent to all his subsequent reasoning, and landed him in erroneous scientific conclusions. "The ridges of lime rock" in the vicinity of Little and Grand Traverse Bays "are, without doubt, a continuation of the line of bearing of the great limestone formation of Wisconsin." So early as this, the ameliorating influence exerted on the climate was distinctly noted. The Indians on Little Traverse Bay, he reports, cultivate somewhat extensive fields of corn, and no failure had occurred within their recollection. "In this respect," he adds, "the country on the western slope is precisely the opposite of that on the northerly and easterly slopes, for this latter district is constantly subject to the chilling influence of the northerly winds from Lake Superior."

In considering the rocks of the northern part of the Peninsula he writes that they "may be regarded as referable to the great carboniferous group of the State, a position to which their fossil contents is amply sufficient to substantiate their claim"; but he makes no paleontological citations in evidence. "In this respect," he continues, "they coincide with the rocks heretofore described as occupying the southern counties; nevertheless it must be borne in mind, as there stated, that these rocks occupy a very different position in the series." It does not appear, however, whether he considered the position higher or lower. "The line of bearing" of the strata, "not only in the northern, but likewise in the southern portion of the peninsula, is regularly northeasterly and southwesterly." As a further conclusion, he infers "that the coal of the central portions of our State and that upon the Illinois River is embraced in a rock which belongs to the same portion of the great basin"—a conclusion which, if borne out, will aid much in determining some important points respecting the relation which the neighboring rocks bear to each other (p. 9). It does not appear whether the "great basin" here referred to is the hydrographic basin of the Mississippi or a great coal basin, nor is it apparent what the "important points" are.

In a similar vein he expresses the conclusion that "that portion of the rock series which in Illinois and Wisconsin embraces the ores of lead is identical with a portion of the rock formation which occurs in the northern part of our own State—a circumstance which might fairly have been inferred from the general line of bearing of the rock" (pp. 9-10). He regards Saginaw Bay as lying in the same "line of bearing" and "occupying a denuded space in the sandstone just at that point where the latter comes in contact with the limestone of the north." He does not indicate, however, which he regards as the overlying formation. He proceeds to describe with the accuracy of a sagacious observer the various kinds of strata appearing at the surface from Point aux Bargues to Mackinac, but he does not discover that limestones of different ages pass under review. The bituminous shale of Sulphur Island did not escape him, but he recorded it as "dipping below the limestone just described," which is that of "the southerly cape of Thunder Bay" (p. 11).

All the localities of limestone, now well known, from Saginaw Bay to the Straits, in the vicinity of the shore, are indicated in this report, and the author gives a correct account of the brecciated mass of Mackinac Island. But he does not state that the limestones hold more than a single geological position. "The old Red Sandstone" in the vicinity of the Porcupine Mountains has been shattered similarly to the limestone at Mackinac Island.

The limestones bordering Little Traverse Bay are noticed, and the ledge on the south shore is thought to overlie that at the head of the bay. The bituminous shale is again detected "just within Grand Traverse Bay" and is compared with that of Thunder Bay.

From Grand Traverse Bay to the southern boundary of the State the immediate shore is destitute of outcrops, but he says "this lime-rock comes to the surface in a hilly region lying between Pere Marquette and White Rivers at a distance of 10 to 12 miles from the shore of Lake Michigan. These outcrops, mostly in Oceana County, are now known to belong to the Carboniferous limestone.

Under the head of Tertiary Clays he says that "a large proportion of the rocks of the peninsula are overlaid by a series of beds of clay, sand, and gravel that sometimes attain a thickness of several hundred feet." This undoubtedly refers to what we now understand as drift. Doctor Houghton seems, however, to embrace here all the incoherent surface deposits, since he notices particularly the stratified clays upon the lake shores. These, in the vicinity of Detroit, are said to be 118 feet thick, and on Lake Michigan 100 to 400 feet. The glacier theory of the drift was not yet in vogue, the great work of Agassiz not appearing until 1840, and his first enunciations at Neuchatel, in 1837, following Charpentier (1834), Venetz (1821), and Playfair (1815).

Dr. Houghton in this report calls attention to beds of shell marl and to deposits of gypsum on the shore of Saginaw Bay, on St. Martins Island near Mackinac, and on the northern Peninsula between Green Bay and Mackinac. He devotes several pages to a statement of facts and traditions bearing on change of level in the waters of the Great Lakes (pp. 20–27).

Speaking next, of the southern part of the Peninsula, he says, "the whole northern part, at least, of Calhoun County is based upon the sandstone series of the great Carboniferous group of rocks." This statement is noteworthy, since later geologists, after assigning the formation to the Devonian system, have returned, on paleontological grounds, to the position which with Doctor Houghton seems to have been almost an inspiration. The clays of Branch County, containing kidney iron ore, he thinks "may probably be referred to one portion of the Carboniferous group, though this connection has not absolutely been shown to exist" (p. 29). The ore he regards as of the "same character as that from which much of the iron of our neighboring State of Ohio is manufactured." The clay is regarded "as of great value in the manufacture of stoneware" (p. 29).

On the subject of coal Doctor Houghton refers to the report of Mr. Douglass, "From facts now before me," he says, "I am led to hope that coal will be found in the elevated hills of the northern part of the Peninsula, easterly from Little Traverse Bay." Later investigations, however, show that these hills are underlaid by Hamilton limestones.

Doctor Houghton speaks with deep interest of the work in the zoological and botanical departments and fully appreciates the inseparableness of geological and topographical investigations.

The report of the State zoologist, Doctor Sager, consists of a catalogue of the known species of animals belonging to the State. The aggregates of the large groups, as there known, are as follows: Mammals, 18 species; birds, 166 species; reptiles, 18 species; amphibians, 11 species; fishes, 22 species; mollusks, 76 species.

The report of the State botanist consists essentially of a list of observed plants in the State, alphabetically arranged.

The topographer's report of 21 pages is arranged under the following heads: Topographical location of Michigan, tables of statistics of the lakes, the lakes and lake coast, depth of the lakes, interior peninsula lakes, periodical rise and fall of water in the lakes, superficies drained by the central and upper divisions of the St. Lawrence Basin, table showing the rise of water from March, 1830, to August, 1838, rivers, United States Survey, Levels, maps, etc.

The report of assistant geologist, C. C. Douglass, covers 11 pages and relates to Ingham, Eaton, and Jackson counties. He says that in T. 3, N. 1 E. a series of isolated ridges begins on section 34 and extends in a northeast direction across sections 13, 23, 24, 26, and 27, having an altitude of from 20 to 80 feet. A second and nearly parallel elevation was noticed, commencing on section 3, in the same township, and extending to section 34 in the adjoining town, having an elevation varying from 20 to 40 feet. A third begins in the south part of Vevey and extends in a northwest direction nearly through the town, varying from 10 to 80 feet in height. At the village of Mason, the Sycamore Creek passes through a ridge of diluvium composed of stratified coarse sand and pebbles, slightly united by a calcareous and ferruginous cement. It will be noticed that these ridges are situated far from any of the morainic ridges mapped by Chamberlin.

After a few pages devoted to timber, marshes and swamps, springs and wells, streams, marl, bog iron ore, crag, bowlders, and clay, Mr. Douglass speaks of the building and flagging stone of Ingham and Eaton counties which he styles "the great sandrock formation." He enumerates many localities and thinks the rock suitable in some of its exposures for flagging and construction. This is chiefly the

Woodville sandstone of later geologists at the top of the coal measures of the State, but at some points the rock is not within the measures, and not unlikely some of the southwestern exposures are of the Parma sandstone or conglomerate. The various exposures of coal in Ingham County are next enumerated.

The report of assistant geologist, Bela Hubbard, consisting of 36 pages, relates to Wayne and Monroe Counties. He treats of Wayne County under the following heads: Topographical features; soil and agricultural character; bowlders; marshes and wet prairies; encroachments of the river and lakes; clay; limerock; marl; peat; bog iron; chalybeate springs; sulphur springs; brine springs; water wells and springs; roads. Monroe County is treated under nearly the same heads. The limerock is discussed no further than to enumerate its various outcrops and describe its character. The outcrops in Monroe County are recognized as lying in several distinct ranges, extending in a northeast and southwest direction. The dip is slated at about 5° northwest or northwest by north. He notices a bed of sandstone included in the formation and describes it as sufficiently pure for glass making. He calls attention to a number of "sink holes," one of which covers nearly 100 acres. The water which accumulates in them disappears "through cavernous apertures in the limestone below." The limestone is designated by Mr. Hubbard "the mountain limerock."

THIRD YEAR OF THE SURVEY, 1839.

The report of the State geologist bears date of February 3, 1840, and, with the accompanying documents, covers 124 pages, of which 33 pages relate to Doctor Houghton's personal observations and studies. A portion of the season had been devoted "to an examination of the southern slope of the part of the Upper Peninsula extending from the Sault de Ste. Marie to the mouth of the Menominee of Green Bay, a district of country which, with very few exceptions, is a perfect wilderness." After a sketch of the physiographic features of this district, in which he points out the prospective importance of the lake fisheries, he approaches its general geology. The rocks, he says, are but little varied, and "consist of a series of well-defined limestones and shales that occupy the complete range from Drummond's Island of Lake Huron to Menominee River of Green Bay. As we proceed toward the declivity of the Upper Peninsula, the red sandstone of Lake Superior makes its appearance, underlying the groups of limestones and shales before mentioned." All these rocks are bounded on the east by a range of hills composed of primary rocks, chiefly of quartz, hornblende, and greenstone. The boundary between them "is nearly defined by the course of the St. Mary River."

Speaking of the primary rocks he says they commence at the contraction of the Montreal Channel of St. Mary River, across the northern part of St. Joseph Island, the southeasterly end of Sugar Island, skirt the easterly side of Great Lake George, forming a range of hills, which, from the head of the lake, passes to Gros Cap of Lake Superior. The primary region thus bounded stretches northwesterly "many hundred miles, skirting a portion of the shores of Lake Superior, and, in conjunction with the trap rocks, constituting the highlands between that lake and Lake of the Woods. From these highlands it stretches a little east of Lake Winnipeg, far to the northwest, finally constituting the immense 'barren grounds' of the British possessions. It is also well known that this range of primary rocks stretches in an easterly direction, through the interior of the upper province of Canada."

After devoting a couple of pages to the surface characters of the primary rocks within the limits of Michigan, he proceeds to the "sedimentary rocks."

The "Lake Superior Sandstone" extends along the south shore of the lake with continuity unbroken, except "by the occurrence of a comparatively limited range of primary and trap rocks." In its easterly prolongation it rests against and upon the primary range of St. Mary River, while on the south it is seen to pass beneath the limestone. He pronounces the sandrock unfit for use in the construction of the St. Mary Canal. This formation, thin on the east, increases westerly to a thickness of several hundred feet. He reports it entirely destitute of fossils.

The formations overlying the sandstone have a slight dip in a direction east of south. Thus, while these rocks dip in such a manner as to form the basins of Lakes Huron and Michigan, their upraised edges form, as it were, the barrier that sustains the waters of Lake Superior at their present level (p. 16). These formations are divided into two groups distinguished by their fossil remains and chemical character, though the line of junction is not readily traced. "The lower limerock and shales" are first considered. These are admirably exposed on the southerly shore of Little Bay du Noquet and pass inland and as far eastward as Drummond Island, thinning in their progress and losing their shales. The upper limerocks overlie Drummond Island and line the lake shore westward to the southerly cape of Green Bay. He thinks they represent three divisions: "The lower or Pentamerus portion; the middle or polypiferous portion, and the upper or Mackinac and Manitoulin portion." These three divisions are well discriminated at various localities, and the middle and lower divisions are more particularly described in their distribution over Drummond Island. The fossils, he says, are "chiefly polyparia, embracing several species of the genera Calamopora, Catenipora, Lyringopora, Aulopora, and Strombodes, together with several species of Orthocera."

These upper and lower limerocks, he thinks, furnish abundant material admirably adapted for use as a building stone, and also for the manufacture of quicklime. He points out the high bluff at the eastern extremity of Drummond Island as a specially favorable locality, and gives a detailed stratigraphical description of the exposure. He indicates, also, the easterly side of Great Bay du Noquet as a locality of the "upper group," which may be made to furnish an inexhaustible supply of good building stone. Gypsum, he says, "forms thin veins in the middle and upper portions of the upper group of limestones. He mentions the St. Martins Islands and several points on the coasts westerly from Mackinac" (p. 24).

The reference to the Lower Peninsula contained in this report furnishes a description of the kidney iron ore deposits of Branch County and contains an allusion to the gypsum at the Rapids of the Grand River, of the value of which he speaks with much confidence.

The report of the State topographer, dated January 12, 1840, covers 18 pages and is accompanied by a map of Wayne County intended to illustrate the scale and style adopted for the county maps of the State. These maps were to be completed from the linear survey plats, with such topographical and geological data laid down as might be collected by geologists in the field. Even to this day we seldom see maps executed with equal finish, clearness, and fullness of physiographic detail. Had Doctor Houghton's plans been carried into complete execution the map of Michigan would still stand the peer of the best work which the union of modern science and modern art has been able to produce. Mr. Higgins reports that the topography of 16 counties is completed, or nearly so, and a general demand is arising for the completion of the engraving. Other points treated by the topographer are the following: Map of lands donated by the United States; extent of donated lands; additional number of Peninsula lakes, the total number of meandered lakes being now 2,297 and the final probable number not less than 3,000; roads and highways; the Chicago turnpike or trail; natural woods of Michigan; variation of the magnetic needle; diurnal variation; errors arising from incorrect observations; decrease of elevation in the waters of the lakes; future prospects of the Peninsula.

The report of assistant geologist C. C. Douglass is dated January 12, 1840, and covers 23 pages. He supplies a geological account of nine counties. As if this were not sufficient for a season's work, he says, in beginning his report:

> In addition to the geological examinations, specimens have been collected illustrating the geology, mineralogy, and soils of the counties examined, and * * * field notes for the construction of accurate topographical maps of nearly every township examined during the past season have been returned to that office [the topographer's].

The counties examined were Jackson, Calhoun, Kalamazoo, Eaton, Ionia, Kent, Ottawa, Van Buren, and Allegan.

In treating these Mr. Douglass gives full details of marls, which are said to occur in nearly every town. He makes brief mention of peat, and devotes a page to clays and sands. He notes the abundance of bowlders of primary rocks; details several occurrences of bog iron ore; mentions kidney ore in Calhoun County; emphasizes the importance of the gypsum of Kent County. Coming to the rocks of the central district of the Peninsula, he recognizes two divisions—"the rocks which overlie or associated with the coal, and those which lie below the lowest coal beds." The latter division is remitted to Mr. Hubbard to discuss, while Mr. Douglass takes the coal series. This series he finds made up as follows:

1. Upper coal strata, consisting of layers of coal, shale, and sandstone.
2. Limestone, found in limited and apparently irregular beds.
3. Sandstone, light gray and red.
4. Lower coal strata, embracing as above, alternating layers of coal, shale, and sandstone.

As to the lower coal strata, Mr. Douglass's demonstrations are not quite satisfactory. He regards the sandstones of Calhoun County as belonging here and believes them to be embraced in the coal measures, because fragments of coal occur in the diluvium at Albion, Penfield, and Battle Creek. The "light gray sandstone" is said to occur near Jackson, and to be quarried in Calhoun, Eaton, and other counties well known to be underlaid by coal. This is the material of the penitentiary in Jackson. The "upper limerock" is cited from Spring Arbor, Parma, Bellevue, and Grand Rapids—all localities now known to be underlaid by the Lower Carboniferous limestone. In supplying the local details of the upper coal group, Mr. Douglass is not conscious that he describes precisely the same coal-bearing strata as he had previously described in Jackson County as constituting the lower coal series; and the limestone described, instead of intervening between the lower and upper coal groups is underneath all the coal-bearing strata. Hence he is led to remark:

> This gives a greater thickness to the coal-basin than had been before supposed, and also proves, what had been previously suggested, that the Grand and

> Maple Rivers and the Tittabawassee and its tributaries occupy the synclinal line of the State, thus accounting for the most copious saline springs being found through that range of country.

In the table of strata of the upper coal measures Mr. Douglass mentions two beds of coal, one of 10 inches, and 5 feet lower, another of 20 inches. The "red sandstone of Ionia County" is thought to hold a place intermediate between the upper and lower coal-bearing rocks.

Referring to Van Buren and Allegan Counties, Mr. Douglass mentions the large angular blocks of reddish-gray sandstone covering an area of 15 to 20 acres on the line between the two counties. This, he confesses his inability "to refer to its place in the sandstone series." The "crag or conglomerate rock" occurring near Richmond, in Allegan County and also on Muskegon Lake is rightly regarded as cemented drift material.

"Limestone bowlders of very large dimensions," says Mr. Douglass, "were noticed in the different counties." In T. 1, S. 14 W. was observed a limestone bowlder of several tons in weight that had been mistaken by the inhabitants for rock in place.

> Near the mouth of the Kalamazoo River, several very large bowlders of blue limestone were noticed, which had been mistaken by the inhabitants for rock in place, and a kiln erected for burning lime. The rock when burnt furnished 1,500 bushels. (Pp. 74, 75.)

The report of assistant geologist Bela Hubbard is dated January 12, 1840, and covers 35 pages. It relates to the counties of Lenawee, Hillsdale, Branch, St. Joseph, Cass, Berrien, Washtenaw, Oakland, and Livingston. The range of his work was similar to that of Mr. Douglass and he alludes to its diversified character and onerousness with a well-justified conviction that shortcomings might reasonably be forgiven. After four pages devoted to topographical features, extent of timber, soils, and scenery, in which the writer's command of a graceful style is pleasingly exemplified, Mr. Hubbard takes up the subject of geology. He points out the position of the Peninsula in relation to the great valley of the Mississippi and comments on the difficulties imposed by the universal sheet of diluvium, in arriving at a knowledge of the succession of formations. These, however, he embraces under the following designations.

Recent formations: IV, Tertiary and diluvial deposits; III, Fossiliferous ferruginous sandstones; II, Kidney iron formation; I, limerock.

The limerock he regards as identical with that which underlies the Valley of the Mississippi, which he designates "the transition or subcarboniferous limestone of European geologists." He thinks it equivalent to the "cliff limestone of Indiana." Referring for details to his description of this formation in his report of the preceding year, he gives here only some of its economical adaptations, suggesting that some of the strata occurring near Monroe may be suited for a hydraulic lime; and he instances for selection the dark blue and the vesicular or volitic strata. He makes additional reference to sand suitable for glass making, which constitutes a stratum through the middle of the formation.

The kidney iron formation is well described and its northern limits traced. It is recognized as immediately underlying the ferruginous sandstone.

The "fossiliferous ferruginous sandstones," since embraced in the "Marshall group," are ranked as "Carboniferous," though, as he says, they all occupy a position below the lowest of the coal beds. This sagacious determination by Mr. Hubbard is particularly to be noted, since the same strata were afterwards for many years on very plausible grounds indentified with the Chemung sandstones of southern New York. Mr. Hubbard gives a stratigraphical table of seven subdivisions. The uppermost sandstone he pronounces a good material for grindstones, and for such use it has subsequently been employed to a large extent. It is the so-called "Napoleon Sandstone." The "yellow fossiliferous sandrock" holds a lower position. The formation shows a slight northerly dip, and its whole thickness "below the lowest of the beds, which embrace coal plants, will be found to exceed 160 feet."

Under the head of "Tertiary and diluvial deposits" Mr. Hubbard refers to evidences of currents of a universal ocean sweeping from the north. He refers to the "diluvial furrows and scratches on the surface of the limerock, to bowlders of primary rocks, and even masses of native copper, which he truly says are no evidence of beds or veins of copper in the vicinity. The blue and yellow clays immediately overlying the limerock of Monroe County, and bordering Lakes Erie and Michigan, are regarded as older than the diluvial deposits consisting chiefly of sand and gravel.

Mr. Hubbard refers, like Mr. Douglass, to "large fragments of limestone occasionally to be met with, which had been disrupted from the transition and carboniferous rocks of the Peninsula. The largest masses of these were found near the summit of the great dividing ridge on its eastern declivity. Several masses in the town of Somerset, Hillsdale County, are of such extent as to be easily mistaken for rock in place, portions only being visible from beneath the imbedding diluvium. I became convinced, however, by the associated fossils that they belong to an older formation than the carboniferous rocks of the vicinity. Bowlders of this rock are so numerous in some parts of the country as to afford almost the supply of lime needed for the district" (p. 91).

Among "recent formations" Mr. Hubbard refers to the singular and extensive "conglomerate" found in Berrien County. "A stratum of gravel cemented with lime appears to be very universal throughout this county, at the depth of a few feet, and extensive masses strongly cemented are frequently found exposed in the faces of ravines and banks of streams, appearing like ledges in place."

On the subject of marl, Mr. Hubbard enters into a well-considered exposition of its nature and uses, and insists upon its great value to the tiller of the soil. Peat is then discussed with similar soundness of views. Bog iron ore and ocher are cited from numerous localities.

Mr. Hubbard finally takes up the consideration of the "ancient lake ridge," devoting six pages to the subject. He traces the ridge through eastern Michigan, finds it to have a uniform elevation of 107 or 108 feet above Lake Erie, concludes that it was not formed during that turbulent state of waters which brought on the diluvial materials, and proceeds to picture the condition of the country at the time when quiet waters filled the basins of the lakes to the height of the wide-extended lake ridge. He holds that the entire basin of the St. Lawrence and the broad valley of the Mississippi were buried under a common inundation, and that it must have been a body of water in direct communication with the ocean. This view necessitates the conclusion that the land then lay at a lower level than at present, and a general uplift has been an event of later date. Still, Mr. Hubbard recognizes the evidence that some portions of the inundating waters must have been fresh and that they stood at different levels at different epochs. These fluctuations he attributes to the occasional destruction of barriers. These views bring out an intelligible distinction between the "diluvium" and "alluvium." The former lies next the Tertiary clays and covers the general interior. It is our "Modified drift." The latter is confined to the lower levels near the lakes and is partially stratified. In this occur remains of trees, mastodon, and fresh-water shells.

Thus three epochs are discriminated: 1. After the elevatory process had commenced and those erosive actions, transportation, and deposition took place, which we now attribute to drift agencies. 2. A period of pauses and barrier formation, when the "lake alluvions would be forming over the area then occupied by the waters." 3. The era of the present levels.

Mr. Hubbard's mind, as shown by these early reports, was prone to contemplate geological phenomena in their broader relations. Being now but a young man of 25 years, he gave evidence of excellent capacity for future usefulness in the field of science.

As to the zoological and botanical departments, Doctor Houghton makes the statement that the several assistants had resigned their positions immediately after the adjournment of the legislature of 1839. No cause of this is given or intimated. It could not have been for lack of appropriations, for these had been made in 1838. The writer [Winchell] on inquiry of Mrs. Sager, who still resides in Ann Arbor, was informed that these resignations were provoked by ignorant criticisms and caricatures indulged in by members of the legislature in public debates on questions connected with the survey, especially in the departments. Subassistant Dr. George H. Bull only had consented to retain his position, and he had been placed in charge of the botanical collections. A year having thus been lost, Doctor Houghton expresses the conviction that "no competent man would be willing to hazard his reputation in attempting, within the space allowed, to complete either the botany or zoology of our State." If the time were extended for these departments "they must in the end be separated from the general work, which will require no such extension." The geological and topographical work the State geologist expected to complete "within the current year (1840) being the time originally assigned by the act authorizing the survey" (p. 32).[1] He therefore suggested a suspension of the zoological and botanical departments. Deeming the bulk of the work yet remaining to be done as lying in the district between Keweenaw Point and the Porcupine Mountains, he alludes to the advantages gained by his previous visit to the region, and expresses the conviction that as the survey is to continue but one year more "the whole will be accomplished within that time."

It is a sufficient commentary on the contrast between earlier and later conceptions of a geological survey to remind the well-informed reader that with all the subsequent study bestowed on the region by Houghton, Jackson, Foster and Whitney, Pumpelly, Irving, and others, the "whole work is not yet accomplished."

FOURTH YEAR OF THE SURVEY, 1840.

The legislature by an act approved March 28, 1840, abolished the zoological and botanical departments, and appropriated $2,000 to meet expenses of preparation of State and county maps on the plan already in progress. The money was to be expended under the direction of the State geologist.

The State geologist's report on the results of the work during 1840, inclusive of the appended documents, covers 184 pages, of which Doctor Houghton's personal contribution is 89 pages. This is by far the most important report of the entire series, both for what Doctor Houghton presents, and for what is contributed by his two geological assistants, Douglass and Hubbard.

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[1] A different construction appears to have been subsequently put upon the act, for the annual appropriations were held to continue till Mar. 1, 1841, which would provide for the work till Mar. 1, 1842.

Doctor Houghton's report is dated February 1, 1841, and his personal statements are devoted to the "northern slope of the Upper Peninsula." Ten pages are occupied with "General description and topographical features." He complains bitterly of the misleading character of the maps of the American border of Lake Superior.

> Scarcely a single feature of the interior is given as actually exists. * * * The coast lines are so defective as scarcely to be recognized, except in their most general outlines.

A comprehensive description of the great physiographic features of the whole Upper Peninsula is followed by a particular enumeration of the principal streams. A general sketch of Ile Royale follows, with a notice of the region west of Pigeon River, on the north shore of Lake Superior as far as the Lake of the Woods, the hilly portion of which, "though of exceeding interest in a geological point of view, is the most desolate that could be conceived" (p. 13).

Under the "General geology of the Upper Peninsula," the following groupings are observed:

1. *Primary rocks.*—These consist chiefly of granite, syenite, and syenitic granite. First seen on the coast at Little Presque Isle, they reappear frequently nearly as far as Huron River and islands, and are thence confined to a range of hills back from the coast, rising 300 to 700 feet above the lake, and continuing in a southwesterly direction. A portion of the southwesterly prolongation of the Porcupine Mountain range is made up of rocks belonging to this group.

But little typical granite is found.

> The more common rock is made up of quartz, feldspar, and hornblende, giving rise to a very dark colored syenite. Occasionally mica enters sufficiently into the compound to form syenitic granite. (P. 23.)

The southeasterly portion of the range is most quartzose. As we proceed norwesterly the rocks approach a quartzless "compound of feldspar and hornblende, which then assumes a granular structure, constituting greenstone." The intermediate rock "may not inappropriately be called a syenitic greenstone."

The primary rocks between Little Presque Isle and Huron River are mostly compact and fine-grained syenite or syenitic granite. In their southwesterly continuation they are largely traversed by dikes "similar in composition to the greenstone before mentioned. These have produced metamorphic changes in the contiguous rocks, extending to several hundred feet." These dikes are regarded as existing in connection with the greenstone. He thinks the chronology deducible from the dikes shows that "the mineral region of the Upper Peninsula is strictly confined to only the outer portion of the rocks of a single epoch" (p. 24).

These veins and dikes of greenstone have no uniform bearing. In width they vary from a mere line to 50 or 60 feet. They disintegrate more rapidly than the contiguous rock.

On the north coast of Lake Superior granitic and syenitic rocks also occur, but "more frequently they are flanked on the south by greenstone, with occasional narrow bands of sandstone; thus precisely reversing the magnetic order of these rocks upon the south" (p. 25).

2. *Trap rocks.*—These flank the primary rocks on the north and northwest, and form a series of ranges of hills stretching generally southwest and northeast, and rising from 300 to 900 feet above the lake. They are less knobby than the primary, but the contrast grows stronger as we recede from the primary. In lithological constitution the contrast follows the same rule. The range beginning at the extremity of Keweenaw Point stretches to the Ontonagon River, gradually receding from the coast. West of this it becomes confounded with the northerly portion of the Porcupine Mountains. West of the mountains the same range is continued to the Montreal River, where it is but 2 miles distant from the lake. West of the mountains is also a second range 12 to 15 miles inland. All the northwest part of Ile Royale is of the same rock.

The age of the trap rocks is subsequent to that of the slates and quartzites denominated metamorphic. The term "trap rocks" includes both greenstone and amygdaloid. Greenstone includes not only those rocks composed of feldspar and hornblende but also those which might more strictly be regarded as altered syenite, syenitic granite, hornblende rock, and augitic rock. Amygdaloid is the same in a certain structural condition.

> The rocks of the outer or northwestern range of hills, which were clearly the last of the series of uplifts, bear more unequivocally the evidence of igneous action. On the south flanks of these hills the rock is invariably very compact greenstone, while upon the northwesterly line it is almost equally invariably an amygdaloid, or at least has an amygdaloidal structure. The cause of this is found in the fact that the uplift of the rocks of this range of hills was wholly upon the southeasterly side, and while the rocks of this portion were in a solidified state; or, in other words, that a point in Lake Superior may be regarded as the fixed axis of the uplifted mass.

This view is confirmed by the undisturbed condition of the sedimentary rocks on the south or southeast, and their highly disturbed condition on the northwest, while the angle of dip diminishes as we recede from the range. These strata have been traversed by numerous and broad dikes, and so altered that in the vicinity of the trap they can be scarcely recognized.

Doctor Houghton in this connection makes some observations of peculiar interest in relation to studies in which geologists are at this moment engaged. He says:

> The rocks of the complete northwestern escarpment of this range of hills were evidently in an intense state of ignition while in contact with the sedimentary rocks, as is clearly shown by the very great changes which have taken place in the rocks last alluded to. In fact, I am disposed to refer the origin of much of the amygdaloid rock to the fusion of the lower portion of the sedimentary rocks referred to, for the reason that, as we pass south from this junction the amygdaloid rocks wholly disappear, their place being supplied by greenstone. And again, so intimately are they blended that it is frequently impossible to determine where the amygdaloid ceases and the upper sedimentary rocks commence. Fragments of the sedimentary rocks, the characters of which can be clearly recognized, are not of rare occurrence imbedded in the amygdaloidal rock, a circumstance which, although by no means conclusive, should not be overlooked in considering this subject. (Pp. 27–8.)

Throughout the entire extent of the "trap range" it is bounded on the north and northwest by hills of conglomerate and sandstones, seldom exceeding 400 feet in height. To the northwest of these "a dike of trap is seen to extend for many miles along the line of coast of Keweenaw Point. It lies in a plane parallel to the stratification of the sedimentary rock by which it is embraced, and with that rock dips to the northwest. The dike is chiefly made up of greenstone, but not unfrequently large portions of the mass consist of amygdaloid in which the amygdules are filled or composed of quartz, chalcedony, agate, calc spar, zeolite, etc."

The dikes just mentioned may be regarded as contemporaneous veins. But another class of veins traverses not only a portion of the trap rocks but also the upper sedimentary rocks. These are true veins.

On Ile Royale the relative positions of the greenstone and amygdaloid are reversed—the latter lying on the south. The same order is observed on the north shore, and here, also, the hills of primary rock lie farthest from the lake.

The trap rocks throughout the region are usually distinctly jointed, and where they approximate to the sedimentary rocks there is, not unfrequently, so distinct a cleavage opposed to the joints in direction, as to give the appearance of stratification. The columnar structure is rudely presented in a few cases, and tolerably well defined columns, having a height of 80 to 90 feet, appear on the northeastern extremity of Ile Royale.

3. *Metamorphic rocks.*—"Flanking the primary rocks on the south, is a series of stratified rocks, consisting of talcose, mica, and

clay, slates, slaty hornblende rock, and quartz rock—the latter constituting by far the largest proportion of the whole group" (p. 17). These rocks stretch into the interior in a southwesterly direction. The average width of the belt does not exceed 6 or 8 miles. The cleavage of the rocks is usually north or N. 10′ W., with an angle of about 80°. The dip of the strata is south or southwest. In the talcose slate, as we approach the granitic region occurs a rock denominated serpentine, but bearing close resemblance to greenstone, being essentially composed of granular feldspar and hornblende, with which serpentine is intimately blended. The metamorphic rocks are occasionally traversed by trap dikes.

4. *Conglomerate.*—This is not known east of the commencement of the trap group, "nor has it been noticed resting upon any of either the primary or metamorphic rocks, but is invariably seen resting upon the trap rocks" (p. 17). It flanks the trap on its northerly side, from the extremity of Keweenaw Point to the head of Lake Superior. On Ile Royale a similar rock rests upon the trap, facing southeast. It forms hills on the south shore 300 to 500 feet high. Its thickness increases westward, being 5,260 feet a little east of Montreal River, and 1,000 feet at its eastern extremity. But the thickness is extremely variable. It may, "without doubt, be considered as a trap tuff which was gradually accumulated around the several conical knobs of trap, during their gradual elevation" (p. 33). The constituent pebbles are rounded masses of greenstone and amygdaloidal trap, with scarcely a pebble of any different rock. They vary in size from that of a pea to several pounds in weight, but average 1½ to 2 inches in diameter. They are generally united by a mixed calcareous and argillaceous cement, more or less colored by iron. It is imperfectly stratified, even in masses of immense thickness. Its dip, on the south shore, is northwest at angles of 30° to 85°. On Ile Royale the dip is reversed. It is frequently traversed by dikes of trap having a thickness of 50 to 60 feet, or even several hundred feet; and these are usually parallel to the plane of stratification. But there are also veins of more recent origin, and these are metalliferous.

5. *Mixed conglomerate and sandrock.*—This is an alternating series of coarse conglomerates and red sandstones, resting conformably on the conglomerates just noticed. They are strictly a member of the conglomerate, and only separated for convenience of description. The formation is 4,200 feet thick on the flanks of the Porcupine Mountains and wedges out in both directions, disappearing near the extremity of Keweenaw Point. The dip is regularly north and northwest into the bed of the lake. It was not noticed on the north shore nor on Ile Royale. The sandstone portions are

about equal in amount to the conglomerates. The materials are similar to the conglomerates; while those of the true sandrock lying above, are chiefly quartzose. The conglomerate and the mixed conglomerates and sandstones are composed essentially of rounded fragments of greenstone, and "the whole may perhaps be regarded as a trap tuff" (p. 37). While the coarser conglomerate scarcely shows lines of stratification, these are very distinct in the sandstones. That the latter were deposited in shoal water is further evinced by the perfectly defined ripple marks. · "Dikes of greenstone occasionally appear in the mixed rock, but they almost invariably occupy places between the strata." There are also many cross veins, made up usually of calcareous spar or a subgranular limestone, and more rarely of some variety of quartz and imperfect amygdaloidal trap.

6. *Lower or red sandstone and shales.*—These cover more space than any other formation. They rest upon the primary or metamorphic rocks, immediately west from Chocolate River, upon the conglomerate and mixed rocks from near Eagle River to the west end of Lake Superior. The situation is similar on Ile Royale and the north shore. These rocks are thickest westward. The predominating rock along the immediate shore of the lake is the red sandstone. The dip on both shores is toward the lake. It flanks all the hills and ranges of primary, metamorphic, and trap rocks. In the sandrock magnetic iron sand is a frequent constituent, sometimes forming strata of several inches. The rock material is cemented by calcareous matter highly colored by peroxide of iron. On the southeast side of Keweenaw Point the exceptional argillaceous strata, found also at several points in the interior, are regarded as constituting a member of the sandstone series. It sometimes appears as a slate, but the usual condition is that of an indurated clay. It is extremely fine; is easily cut with a knife, and the Indians have long been accustomed to work it into pipes.

The rocks of the red sandstone formation are abundantly and beautifully characterized by ripple marks. Of fossils, nothing but some fucoids has been discovered, "of which there are three species pretty well defined."[1]

But few dikes intersect the sandstone, except where the intervening conglomerate and mixed rocks are wanting. Here the sandstone assumes a deep brown color, "and the material of which the sand is composed gradually changes from that before described to greenstone" (p. 40).

The greatest thickness at the west was estimated at 6,500 feet. It is regularly alternated eastward. The average rate of alternation is about 15 feet a mile. Inland the formation thins more rapidly. The thickening northward is attributed to the later upheaval of the northern ranges.

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[1] These have been described by the writer [i. e., A. Winchell] as two species. See Amer. Jour. Sci., ser. 2, vol. 37, pp. 226–233, 1864.

7. *The upper or gray sandstone.*—This formation is "first noticed, rising in hills, at a point not far distant from the River Ste. Marie (at the Neebish Rapids) and southeast from Point Iroquois; from this point it stretches westerly in an elevated and very regular chain of hills that are upon the coast as far as Tequamenon Bay; westerly from which, the shape of the coast is such that these hills do not again appear upon it until we reach that precipitous portion of the lake coast known as the Pictured Rocks" (p. 42). Westerly from these the ranges of hills formed of this sandstone stretch in a southwesterly direction, passing completely to the south of the primary trap and metamorphic regions. This sandrock differs from the lower in being more exclusively quartz, and also in having a south or southwesterly dip, conformably with the overlying limestone, while the lower sandrock dips toward the lake, and its outcropping edges are covered by the upper and newer. The average thickness of the upper sandrock as far west as the Pictured Rocks is thought to be about 700 feet.

8. *Sandy limerock.*—Feebly represented on Sailors Encampment Island, it stretches westward, nearly along the middle line of the Peninsula, with a width of 10 to 15 miles, dipping uniformly to the south-southeast.

Above this succeed the lower limerock and shales and the upper limerock group (Drummond Island and Mackinac limestone) described in the third annual report. Covering the general surface, lie the incoherent materials designated "Tertiary clays and sands."

Doctor Houghton next proceeds, in the fourth annual report, to consider "Economical geology." After referring to the valuable building materials supplied by the granites and syenitic granites, and the moderate promise of the red and gray sandstones for the same purpose, he proceeds to the subject of "Minerals and mineral veins."[1] He gives separate lists of the minerals occurring in the several formations before described, and then devotes 31 pages to "Mineral veins of the trap, conglomerate, etc."

Veins of date posterior to the uplift of the most northern range are of frequent occurrence. They not only traverse a portion of the trap range, but also pass into the conglomerate, and sometimes completely across the three sedimentary beds immediately above the trap. They rarely vary more than 12° to 15° from a right angle to the line of bearing of the sedimentary rocks, and in pursuing this course they necessarily cut across the dikes of trap which lie between the strata. These veins all belong to one epoch. They present complete uniformity of characters—when they traverse continuous ranges of the trap, they are regular in course and direction; but in a single knob they are irregular and undefined. They contain metalliferous materials which "will hereafter become of very considerable practical importance." It is true that native copper occurs "occupying the joints or natural septa of the greenstone, but in these instances the amount of metal is comparatively small, and, with one or two exceptions, I have invariably been able to establish some connection between the native metal occupying these joints and the termination of some metalliferous vein that traverses other portions of the rock not far distant."

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[1] This portion of the report, amounting to 33 pages, was reprinted entire in "The Mineral Region of Lake Superior." By Jacob Houghton, jr., pp. 36–79. Buffalo, 1846.

Arguing that the richest veins would be found along the line of contact of the trap with the sedimentary rocks, great pains had been taken to trace that line across the country. It was found to diverge gradually from the lake in its westward extension. The theory was confirmed that the trap is the source of the copper occupying the veins, since as soon as the veins enter the sandrock they contain no ores but those of zinc and iron (p. 54).

The metalliferous veins, Doctor Houghton continues, seem to originate in the northern or amygdaloidal trap. They cross the trap range nearly at right angles to its axis, and frequently continue the same course across the sedimentary rocks. But the width of the vein is greatly diminished in the greenstone.

> It increases in width rapidly as it passes across the amygdaloid, and at or near the junction between the amygdaloid and the sedimentary rocks, it will frequently be found to have attained a thickness of several feet, while in its passage across the sedimentary rocks, it is usually either further increased in width or becomes so blended with rock itself as to render it difficult to define its boundaries.

In the amygdaloid the veinstone is mostly quartz; in the conglomerate and sandstone, it is mostly calcareous, and finally ceases to be metalliferous. The metalliferous character is most fully developed near the line of junction of the trap and sedimentary rocks. The most abundant metallic minerals are the several ores of copper. Very frequently native copper occurs, and very rarely, silver. The native copper is often disseminated through the quartzose veinstone, the rocky matter embraced in the veinstone and the amygdaloid and conglomerate, sometimes to the distance of 2 or 3 feet, completely filling the cells of the amygdaloid. In other portions of the vein the native copper is concentrated in larger masses, constituting bunches and strings; and in some places the walls of the veins are wholly made up of native copper. In these places the ores of copper are scant, and the presumption is favored that the origin of the ore is chiefly from that which was previously in a native form (p. 60).

Veins of similar character occur on Ile Royale, and a similar relation is observed between the veins and the formations traversed; but the order of change is reversed in direction.

A brief description is given of the peculiar constitution of the trap knob of Presque Isle and its innumerable ramifying veins; and mention is made of a red slate formation resting against the southerly slope of the greenstone range, "which is traversed by irregular and imperfect veins of what may be regarded a ferruginous steatite, and a small amount of ores of copper." These veins, however, are not supposed to have any connection with those in the amygdaloid.

With a view to ascertaining what expectations may be based on the facts thus far observed, Doctor Houghton presents quite an extended comparison with the copper and tin veins of Cornwall. His final prognostication is decidedly conservative, and it seems to be rendered so by the very circumstance which has constituted almost the exclusive resource for profitable copper mining in this district. He says:

> I confess that the preponderance of native to the other forms of copper was regarded as an unfavorable indication, at least until this had been found to be more or less universal with respect to all the veins. (P. 74.) * * * While the mineral district will prove a source of wealth to the people, I can not fail to have before me the fear that it may prove the ruin of hundreds of adventurers, who will visit it with expectations never to be realized. (P. 76.)

Doctor Houghton next devotes three pages to the "Soil and timber of the Upper Peninsula," and five pages to "Furs, fish, and harbors of Lake Superior."

Thus closes a report which, for extent of territory covered, brevity of period devoted to the work, arduousness of field exploration, and, above all, amount of original matter and soundness of conclusions, is certainly one of the most remarkable reports ever published. But Doctor Houghton has found the work "considerably more than he had reason to look for" and discovers that it can not be completed within the time which, a year before, he had thought sufficient.

To this is appended a brief report by special assistant Frederick Hubbard on "latitudes, magnetic variations, etc"; and then follows that of assistant geologist C. C. Douglass, dated January 4, 1841, and covering 15 pages, and treating of the northern part of the lower peninsula. Under the head of "General character" of this region he embodies some physiographic statements. He speaks of the Grand and Little Traverse country as "well adapted to purposes of agriculture." He writes that the capabilities of the region north of the Grand River are not at all inferior to those on the south; says the Indians on Grand and Little Traverse Bays "obtain good crops of corn, potatoes, squashes, etc. Some of the most intelligent Indians informed me that their crops have never been known to fail entirely, and that they were seldom injured by frosts in the fall or spring. They also have many apple trees which produce fruit in considerable quantities" (p. 101). Yet for 20 years after this the capabilities of this region remained unappreciated.[1] Mr. Douglass, however, does not seem to have understood that these results depended on the influence of Lake Michigan during the winter and the frosty portions of the spring and autumn; for he says:

> The soil is strictly a "warm one" and exposed, as the whole country bordering on Lake Michigan is, to the influence of the southern winds during summer and parts of spring and fall, it seldom fails to be productive.

Coming to the "General geology," Mr. Douglass begins with two stratigraphical tables, which it seems best to reproduce:

1. Rocks of Lake Michigan.

1. Tertiary and superficial materials—
    1. Bowlders of granite, etc.
    2. Clay, sand, etc.
2. T. 16 N. Manistee limestone.
3. T. 31–32 N. Shales—
    1. Light blue, argillaceous.
    2. Black, containing pyrites.
4. T. 33 N. Corniferous. Containing beds of hornstone.
5. T. 34 N. Little Traverse Bay limestone. Beds of limestone intermixed with clay and chert.
6. T. 34 N. Black bituminous limestone. Composed of congeries of shells.
7. T. 34 N. Blue limestone in thick regular layers.
8. Mackinac limestone. Very porous and much shattered.

2. Rocks as seen from the coast of Lake Huron.

1. Alluvium—
    1. Beds of rivers.
    2. Incrusting springs.
    3. Marl, tufa, peat, etc.
2. Tertiary and superficial—
    1. Bowlders of granite.
    2. Beds of clay and sand, etc.

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[1] The climatic and agricultural characters of the region have more recently been set forth by the writer [Winchell] in sundry publications. See Report on the Grand Traverse Region, octavo, pp. 92, with map, 1866; The Fruit Belt of Michigan, Proc. Amer. Assoc., 1866; The Isothermals of the Lake Region, Proc. Amer. Assoc., 1870, appended also to the writer's Report on the Progress of the State Geological Survey, 1870, and abstract published in the Zeitschrift der österreichischen Gesellschaft für Meteorologie, in Vienna, vol. 8, p. 40 seq. Feb. 1, 1873; The Climate of the Lake Region, with two charts, Harpers' Magazine, July, 1871, republished entire in Der Michigan Wegweiser, Hamburg, 1873; also Michigan, being condensed Popular Sketches of the Topography, Climate, and Geology of the State, 1873, pp. 89–121, with isothermal charts in colors; and finally, The Climate of Michigan, Ann. Report State Horticultural Society, 1880, pp. 155–163.

3. 20, 26, N. Point au Gres limestone. Light colored arenaceous, containing septaria.
4. 27 N. Shale. Black, bituminous, containing pyrites.
5. 28 N. Thunder Bay limestone. Beds of limestone and gray clay or shale, containing abundant fossils.
6. 30, 31 N. Black bituminous limestone. Bituminous, composed of congeries of shells.
7. 32, 33 N. Blue limestone. Compact and in thick strata.
8. Mackinac limestone. Very porous, and the upper portion much shattered.

"It will be seen," adds Mr. Douglass, "that the same rock, with one or two exceptions, occurs on both sides of the State, having the same geological position; also that they have very nearly parallel and uniform positions. And from the outcrops the rocks would appear to have a bearing nearly N. 70° W. and S. 70° E., which line of bearing corresponds with the outcrop of the black bituminous slate on the east side of Lake Huron in Upper Canada" (p. 103). Doctor Houghton had already fixed the "line of bearing" northeast and southwest. The Michigan geologists thus far had not attained to the conception of a dishlike arrangement of the strata. They thought the outcrops must strike across the Peninsula, nearly in straight lines.

The "Manistee limestone" is unknown to the writer [Winchell]. Moreover, the Manistee River, near which in township 15 north, limestone is stated in the accompanying text to occur, is located entirely north of township 15. On the other hand, in township 15 and near the Pentwater River in Oceana County, occur masses of limestone, which the writer has referred to the Lower Carboniferous.[1]

The "Shales" in township 31–32 north, outcrop on Grand Traverse Bay and constitute the writer's "Huron group," the black shale being the "Genesee." The "Corniferous limestone" is not definitely located by Mr. Douglass; but in township 33 we find limestone answering to the description, outcropping on the lake shore between the mouths of Grand and Little Traverse Bays. It belongs near the top of the Hamilton group, and its stratigraphical position is correctly indicated. The "Little Traverse Bay limestone" belongs at the bottom of the Hamilton group. The "Black bituminous limestone" is not considered by the writer to occur at a lower horizon than the last, but between it and the so-called "Corniferous." The "Blue limestone," also is embraced in the Hamilton.

As to the rocks of Lake Huron, the "Point au Gres limestone" is an arenaceous stratum in the lower part of the Lower Carboniferous limestone. The "shale" is the black Genesee shale. The "Thunder Bay limestone" belongs in the lower part of the Hamilton, and the "Black bituminous limestone" holds a higher—not a lower—position.

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[1] Winchell, Proc. Amer. Assoc., 1875, p. 36.

The "Blue limestone" is probably not the equivalent of the "Blue limestone" of Lake Michigan, as it seems to belong in the lower position to which Mr. Douglass here assigns it.

The report of assistant geologist Bela Hubbard is dated January 24, 1841, and occupies 34 pages. It proposes "to exhibit a comprehensive view of all the rock formation throughout the organized counties of the State." It is prefaced by a general section, which is here reproduced:

A. Erratic block group, or Diluviums. *a*, Alluviums, ancient and recent.
B. Tertiary clays.
C. Coal measures—Upper coal and shales, lower coal and shales, included sand stones, limestone stratum.
D. Subcarboniferous sandstones.
E. Clay and kidney-ironstone formation.
F. Sandstone of Point aux Barques.
G. Argillaceous shales and flags of Lake Huron.
H. Soft, light-colored sandstones.
I. Black aluminous slate.
K. Limerocks of Lake Erie.

Speaking of the "Erratic block group," he says, "this whole deposit is one of transport by water." And again:

> Whatever may have been the causes which swept these materials over the face of the rocks, whether oceanic currents or bodies of floating ice, the character of the diluviums, as well as numerous accompanying facts, plainly implies that they came in a direction northerly from their present beds, and often from great distances.

Mr. Hubbard devotes six pages to a very intelligent discussion of the physical features of this formation. But it must be understood that the formation which he has in mind is what we often style the "modified drift."

By "ancient alluvions" he designates what are often termed "lacustrine deposits, embraced between the ancient lake ridge and the present shores of the lakes." He does not here affirm that these are underlaid by the "diluvium," for this, he says, "overspreads the whole interior of the State beyond this separating ridge." Still there is room to suppose that Mr. Hubbard refers only to what appears on the actual surface. By "ancient alluvions" he designates deposits still in progress, like marl, bog iron, and peat. In the ancient alluvion have been discovered bones of the mastodon in Macomb County, and on the Paw Paw River in Berrien County. A vertebra, pronounced by Doctor Sager to be the caudal vertebra of a whale, was found some years previously on the St. Joseph River. It had a vertical diameter of 18 inches, a transverse of 2 feet, with diameter of body, 11 inches; length of body, 10½ inches; length of spinous process, 9 inches; and weight of 21 pounds.

By "Tertiary clays" Mr. Hubbard understands what we now designate "bowlder clay" or "till." They cover all the border counties on the east and west slopes of the peninsula, and in some cases stretch far inland. The Tertiary clays underlie the ancient alluvions "throughout their whole extent. These are a formation anterior to both the diluviums and alluvions, and are frequently found extending far beyond the old lake ridge" (p. 122).

Under the head of "Coal Measures" the "limestone stratum" is so defined as to indicate its identity with the lower Carboniferous limestone. He adopts Mr. Douglass's views respecting the existence of "lower" and "upper" coal beds. The lower coal, he thinks, gives promise of much usefulness. He recognizes it in Jackson, Ingham, and Shiawassee counties, and says it is 3½ to 4 feet thick near Corunna. The accompanying shales extend as far east as Flint River in Genesee County. "The coal of Shiawassee and Flint Rivers appears to occupy the extreme edge of the coal basin" (p. 127). The upper coal is recognized "as the northern part of Eaton County," and probably underlies the whole of Clinton and Gratiot Counties. In quality and thickness it is inferior to the lower coal. With the "included sandstones" he associates the gritstones at Napoleon. The "red or variegated sandstone" of Clinton and Ionia Counties he thinks belongs between the upper and lower coals.

The "subcarboniferous sandstones" are the same as heretofore designated "fossiliferous, ferruginous sandstones," and are more recently known as "Marshall sandstones." He says "they make their appearance at its eastern edge, on Lake Huron, near the entrance of Saginaw Bay." He seems to refer here to the Point au Gres sandstone, which is a stratum in the lower Carboniferous limestone. The "Point aux Barques sandstones," which are their real equivalents, are treated under a separate head.

The "clay and kidney-ironstone formation" is the upper and larger portion of the "Huron group" of the writer [Winchell], and lies undoubtedly in the horizon of the Chemung and Portage groups of New York.

The "sandstones of Point aux Barques," it is stated, stretch southwesterly, along the swell of land which forms the summit level of the Peninsula, into Hillsdale County, "where the green and yellow fossiliferrous sandstones above described overlie them." But no such relation of superposition has been observed. Did it exist, the "kidney iron formation" would be between, and this has a thickness of several hundred feet. In fact, the "Point aux Barques sandstones" trend southwesterly and are in continuity with the sandstones of Hillsdale County.

The "argillaceous shales and flags of Lake Huron" are to be identified with the "kidney iron formations." This results from the identification of the overlying sandstones of the two. Of this formation, Mr. Hubbard records the following interesting statements:

> These slates and alternating sandstones may be considered as the upper salt rock of our State. They have been passed through in boring for salt at Grand Rapids, and found to yield strong supplies of brine. At this point they are found also to alternate with beds of gypsum and gypseous marls, as will appear by reference to the table of the strata passed through, given on a subsequent page. The thickness ascertained to these slates at that point is about 170 feet.

An examination of the table referred to shows that the alternating beds of gypsum and shale are the real "Michigan salt group," lying immediately below the lower Carboniferous lime and holding position very far above the "shales and flags of Lake Huron." The identifications by Mr. Hubbard would locate the gypseous shales of Grand Rapids not only below the Point aux Barques sandstones, but below the kidney iron formation; while the table of borings cited shows them immediately below the limestone which he regards as the bottom rock of the Coal Measures.

The "soft, light-colored sandstones" are described in the text as "generally of a dark color." Mr. Hubbard states that they have been penetrated in the borings at Grand Rapids, 230 feet; that they "evidently" form the bed of Lake Huron near its foot, but do not make their appearance at any point on the coast of the Peninsula (p. 133). In reality it does not appear evident that they lie on the bed of Lake Huron. This is only an inference from the erroneous identification of the gypseous shales at Grand Rapids with the "shales and flags of Lake Huron." These sandstones, known only under the gypseous shales of Grand Rapids, are identical with the Hillsdale County sandstones. They are the Marshall sandstone, and outcrop as a "soft, light gray sandstone in Ottawa County, near Holland." In Mr. Hubbard's table, therefore, D, F, and H are identical and E and G are identical.

The "black aluminous slate" is the well-known Genesee shale; and the "limerocks of Lake Erie" are chiefly the modern "corniferous," but with the "water lime" of the Lower Helderberg exposed in the lowest positions.

Mr. Hubbard makes statements as follows respecting the dips of the rocks:

> On the eastern slope of the Peninsula, south of Saginaw Bay, northwesterly; while the dip along the southerly and westerly border of the basin of coal-bearing rocks is such as to indicate the counties of Clinton and Gratiot as occupying nearly the central part of the coal basin (p. 137).

He thinks the coal beds may extend as far north as township 23, on the head waters of the Muskegon and Tittabawassee Rivers. The coal basin, then, is "nearly oval in form, whose center very nearly corresponds with the true center of the Peninsula." Mr. Hubbard omits to state the dips of the strata on Lake Huron north of Saginaw Bay, or along any part of Lake Michigan, or on the northern border of the Peninsula. He does not identify the Mackinac and Monroe limestones. In these latest utterances of the early Michigan geologists respecting the Lower Peninsula we find revealed only a partial conception of the complete dish-like arrangement of the entire body of strata.

In connection with a statement of strata passed in Lyon's salt well at Grand Rapids, Mr. Hubbard assumes that the Hillsdale County sandstones have here "thinned out," and it is on this ground that he thinks the gypseous shales to occupy the position of the "Hudson flags and shales." It is not intelligible why he did not rather identify them with the "kidney iron shales." Two beds of beautiful gypsum were passed 4 to 6 feet in thickness. On the relation of the brines he says:

> The strongest brine springs make their appearance along a line which will be found to correspond with the synclinal axis, or axis of the dip of the rocks composing the great peninsula basin—a circumstance which would be looked for from the fact that the ordinary law of gravitation would conduct the strong brines to the lowest levels of the rock strata. (P. 138.)

The gypseous clays of Grand Rapids constitute the "upper salt rock" and yield a brine, as he states, stronger than that in Ohio, which sustains a profitable manufacture. But the brine obtained in Lyon's well, at a depth below 230 feet, "may be supposed to proceed by veins from the 'lower salt rock,' lying at a still greater depth, and from which the strongest and best supplies of brine in our State may be expected." Mr. Hubbard gives no description from which we can identfy his "lower salt rock." We now know that a "lower salt rock" (the Salina formation) actually exists: and there are people who claim that this was in the eye of the Michigan geologist (generally, however, supposed to be Doctor Houghton), though, so far as evidence goes, Mr. Hubbard was the only one who had attained this view. But it does not appear how the brine could rise from it through a fissure to the higher levels, since so few fissures were known in the intervening formations; and these were of so argillaceous a character as not to admit of permanent fissures; and if the fissures had existed, the brine, as Mr. Hubbard correctly reasoned, would descend instead of ascending.

With a comprehensive but condensed review of the economic products of the southern portion of the Peninsula, and some far-seeing and statesmanlike reflections on the progress and prospects of the State, Mr. Hubbard brings his somewhat remarkable report to a conclusion.

The report of S. W. Higgins, the topographer, is dated January 24, 1841, and covers 26 pages. It embodies a valuable memoir on the "Variation of the magnetic needle." The other topics treated are "County surveyors"; "Area of the Lower Peninsula," which he makes 41,304 square miles; "Elevation and depression in the water of the Great Lakes"; and "Marshes."

FIFTH YEAR OF THE SURVEY, 1841.

By a joint resolution, approved Febraury 2, 1841, the State geologist was instructed to act as commissioner on the part of Michigan in relation to the boundary line between this State and Wisconsin.

By an act approved February 8, 1841, the board of internal improvement was required to supply the State geologist with requisite data for mapping improvements, but no new surveys were permitted to exceed $25.

On the 20th of March, 1841, a joint resolution was adopted looking to the encouragement of copper smelting in the United States.

The report of the State geologist on the operations of this year is dated January 25, 1842, and occupies less than six pages. He says:

> The geological and topographical surveys have progressed steadily toward completion, though, in consequence of the reduction of the number engaged in the work, which became necessary in consequence of the comparatively small amount of funds applicable to that object. the amount of work accomplished has been somewhat less than that of the preceding year. The labor so applied has been chiefly devoted to the westerly portion of the Upper Peninsula, including a part of that which may be designated as the mountainous district of the State.

He speaks of duties assigned relative to the boundary line between this State and Wisconsin. and says he has completed "a very perfect geological section nearly 180 miles in length, crossing from the mouth of the Montreal River of Lake Superior, to the mouth of the Menominee River of Green Bay. A large amount of work has been performed in the mountainous region, stretching from Montreal River to Ontonagon River, and extending southerly from Lake Superior, a distance of some 40 miles. including what may be termed the westerly portion of the copper district within our State. All the rivers between and including the two named have been carefully examined to their sources, and the Porcupine Mountains have been traced out through almost their entire range. The copper ores associated with the altered conglomerate and sandstone rocks in *this* portion of the range have been found to be more extensive than was originally supposed."

He finds the southerly range of mountains before referred to, beginning near the mouth of the Chocolate River, to be continued across the Menominee River into Wisconsin. "Within the limit of this range would fall the lead district of Wisconsin and Iowa"; but he gives reasons for thinking no heavy deposits of lead will be found in Michigan.

He remarks that the "field work of the geological and topographical surveys upon the plan originally contemplated, is now mainly completed"; but a large amount of laboratory and office work must yet be performed in preparation for a final report. As the funds set apart for the survey are now exhausted, and the survey expires by limitations, he asks a small appropriation for the completion of the work. He states that maps of the counties of Hillsdale, Lenawee, Branch, Calhoun, Jackson, and Washtenaw have been engraved, and enumerates 13 others as ready for the engraver. Wayne had been engraved in 1839, and it does not appear why it is not enumerated with the others. Of the $2,000 appropriated March 28, 1840, for the map of the State, $1,500 remained unexpended; I am unable to ascertain whether this became available.

SIXTH YEAR OF THE SURVEY, 1842.

Though no legislation was had perpetuating the survey after the expiration of the four years for which provision was made in 1838, the office of State geologist was not abolished, and I find that $3,700 were paid out of the State treasury for salaries of geologist and topographer and for other purposes. It is probable, however, that some portion of this was a balance from the old appropriation. Gov. John S. Barry, in his message to the legislature of 1843, after enumerating the great desirability of geological surveys, and announcing the substantial completion of the field work though much office work remained, says:

> If the commencement of a geological survey of the State was now a question presented for consideration, I should have no hesitation in recommending its postponement; and whilst I think the survey now in progress was prematurely undertaken, yet, as it is so nearly brought to a close, true economy seems to require its completion.[1]

The sixth annual report of the State geologist is dated January 31, 1843, and fills but four pages. It shows that most of his time during 1842 was occupied in office work. Doctor Houghton writes that the field work for the entire survey is completed, with the exception of some few points where the work still wants connecting, and which will not involve any material expense. He apologizes for the delay in the completion of the county maps, stating his inability to procure such funds as would enable him to purchase paper for striking them off. At last he ordered 1,000 each, of six of our most populous counties, but, to his deep mortification and regret, they had not yet arrived. He hopes to realize something from their sale. He refers again to the arduous character of the duties performed, and adds:

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[1] Joint Documents, 1843, p. 39.

> The labor has been rendered light by the hope that in aiding to develop the resources of our State, in placing upon maps, her geology, topography, and the character of her timber and soil, her settlement might be increased, and something added to her property and wealth.

The first financial exhibit made by Doctor Houghton in his entire series of reports is the ludicrous statement which I here in substance append:

By amount from last fiscal year[1]		$1.42
Appropriated for 1842		400.00
		$401.42
To amount paid sundry bills	$250.61	
Rent of geographical office, etc	50.33	
Drafting, paper, stationery, binding	74.83	
Postage	19.47	
		395.24
Balance in hands of State treasurer		$6.18

He asks $300 for the next year.

SEVENTH YEAR OF THE SURVEY, 1843.

Gov. John S. Barry in his message of January 1, 1844, repeats the statement that the survey has been steadily progressing toward completion. He says the engraving of four of the county maps has been completed and the maps received. He suggests that in cases where the engraving of a county map has not been commenced the work be suspended, and adds:

> It is desirable, if it can be accomplished, to take advantage of the surveys about to be carried forward by the United States in the mineral district of the Upper Peninsula, for the purpose of perfecting the geological surveys in that district. If this can be effected it is believed that a more perfect geological map may be made than is to be found in any other State, and that without any additional expense.[2] A part of the final report of the State geologist will be ready for publication during the present year, and an appropriation will be required for that purpose.

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[1] This is probably Doctor Houghton's account with the fund for incidental expenses. The summary financial statement hereafter introduced seems to be in conflict with this.

[2] Joint Documents, 1844, p. 14.

The annual report of the State geologist is dated February 15, 1844, and consists of three pages. It shows that besides the four county maps which have been struck off and placed on the market, 10 others are in the engraver's hands. An appropriation is asked for $1,000 or $1,500 to continue the map publishing until the sales meet expenses. He justly expresses the conviction that these maps "will be more full and perfect than any that have heretofore been published of any equal portion of the United States. The final report on the Lower Peninsula, with all the maps and sections. will, I trust, be ready for the press during the coming summer. The engraving of the geological sections, fossils, etc., has been conditionally contracted for; but the continuance of the work requires financial provision."

He speaks of the opportunity afforded by the United States linear surveys for perfecting the geology of the Upper Peninsula.

> All that would be required would be simply a permission from the Commissioner of the General Land Office of the United States to the geologist of Michigan to require the deputy surveyors to make certain observations during the progress of their survey, of a character which would connect the geological survey of our State with the linear survey of the United States. I hope to perfect such an arrangement in this particular as will enable me to produce more perfect geological and topographical maps of the Upper Peninsula than have ever been constructed of the same extent of territory in the United States.

He asks for $400 for current expenses, in addition to what may be appropriated for county maps, wood engravings, and final publication.

EIGHTH YEAR OF THE SURVEY, 1844.

The State no longer maintained a geological survey. The published documents do not reveal the existence of any report from the State geologist on the operations of 1844. The message of Gov. John S. Barry, however, explains the lacuna, and from this I make the following extracts:

> The field work of the geological and topographical survey of the Lower Peninsula of the State has been brought to a close, and much has been done toward preparing the final report upon this portion of the work. The engraving of the illustrations necessary to accompany the volumes when published has been in progress during most of the year; but some further time will be required for its completion.
>
> In consequence of the deficiency of the means required to finish the surveys of the Upper Peninsula with the same minuteness that they had been done in the lower, the State geologist had determined at one time to make the final report upon that part of the work, in a more general manner; but during the past year, such a connection of those surveys has been made with the United States lineal surveys as will insure, without expense to the State, their completion in the most perfect manner. By this arrangement the General Government lends its aid in perfecting our geological surveys. The practicability of the plan was

fully tested the last season, and its utility satisfactorily established. The whole work is performed at the expense of the General Government, under the direction of the State geologist, pursuant to a contract by that officer with the surveyor general.

Thus the first geological survey of Michigan appears to have expired for lack of sustenance, like several others inaugurated nearly at the same time, conducted with distinguished ability while funds lasted, and finally crushed beneath the widespread financial disasters of the times.

Doctor Houghton had long feared this and long struggled in hope of carrying through his cherished enterprises. But, finding the disaster inevitable, he had for two years meditated the project to which Governor Barry refers in the passage above quoted.

This plan was fully set forth in a paper prepared and read by him before the Association of American Geologists at Washington in 1844. The advantages of such a combination were at once comprehended, and the project was warmly endorsed. The land commissioner, however, fearing the ordinary surveyors would not possess sufficient geological information, hesitated until Doctor Houghton himself offered to take the contract. This contract was signed June 25, 1844, and the remainder of that season and the season of 1845 were occupied in completing preparations and carrying on the work.

NINTH YEAR OF THE SURVEY, 1845.

Doctor Houghton, though for two years receiving no aid from the State, was still recognized as State geologist. His contract with the surveyor general was nearly completed when the lamentable event occurred which put an end to his zealous and useful activity in the development of the natural resources of his adopted State. The notes and maps of three townships were in Doctor Houghton's possession at the time of his death, and were never recovered.[1] These are T. 58 N. 29 and 32 W; and T. 59 N. 29 W., near the extremity of the Keweenaw Point, on the north shore.

The administrators of Doctor Houghton's estate (Henry N. Walker and Samuel T. Douglass) provided for a careful inspection of the field notes and the preparation of reports to be transmitted to the surveyor general, Lucius Lyon. Their communication covering these reports bears date February 16, 1846. One of the reports was prepared by William A. Burt, the inventor of the solar compass, who had been Dr. Houghton's principal assistant in the field during

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[1] See Reports on the Linear Surveys with reference to Mines and Minerals in the Northern Peninsula of Michigan in the years 1845–46. Octavo. Washington (printed 1849); Annual Message and Accompanying Documents, Part 3, pp. 802–842, also pp. 933–935.

1845. The other was prepared by Bela Hubbard, late assistant State geologist.

These reports do not embody any considerable amount of new matter. They treat the subject under the subdivisions made by Doctor Houghton in his Fourth State Report and reproduce Doctor Houghton's views. As the reports were drawn up for general readers, to whom Doctor Houghton's reports would be probably unknown, they embrace many repetitions of matters contained in the State reports. Some of the more important additions will be here mentioned.[1]

Judge Burt's report covers Keweenaw Point and the country from Chocolate River to Carp River, along the south shore of Lake Superior. He treats of the topography and other matters under the following heads: Soil and timber; Streams and harbors; Trap range of Keweenaw Point, etc.; Lake coast harbors; Rivers; Porcupine Mountains; Geology, Primary rocks; Argillaceous slates; Red and variegated sandstone; Conglomerate rock; Veins and limestone. Then, proceeding westward from Keweenaw Point, he discusses Argillaceous slates; Red sandstones; Trap and conglomerate rocks of the Porcupine Mountains, and drift.

Speaking of the metamorphic rocks stretching southwest from the lower falls of the Riviére du Mort, he says:

> A few veins of quartz were seen traversing these rocks, but no one was observed to be metalliferous. I have, however, seen specimens of specular iron ore said to have been obtained in township 48 north, range 26 west.

In respect to the primary rocks he says:

> No vein indicating a workable quantity of metal of any kind was observed; but it should not be inferred from this that they do not exist here.

As to the veins, in addition to treating them nearly in the same manner as Doctor Houghton had done, he writes that "their metalliferous character is developed along the junction of the trap and sedimentary rocks on both sides of the trap range." Doctor Houghton had only spoken of it on the north side.

The argillaceous slates previously reported by Doctor Houghton on the southeast side of Keweenaw Bay are reported by Mr. Burt 3 or 4 miles east of the Porcupine Mountains, where they dip 15 to 45° in a direction between northeast and southeast. From these facts Mr. Burt infers that they pass under the sandstone to the east of them.

The red sandstone west of Keweenaw Point is supposed to belong to the same formation as that to the east. "Its general character is the same, except that in some places it contains more mica." Its dip is north northwest.

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[1] Senate Documents, 1st sess., 29th Cong., 1845–46, vol. 7, Doc. 357. 29 pp. These reports are reprinted in Mineral Region of Lake Superior. By Jacob Houghton, jr. pp. 83–123. 1846.

The report compiled by Mr. Hubbard treats the general subject under the following subdivisions: Granite rocks; Metamorphic Group; Clay slate; Red sandrock; Keweenaw Point; Trap rocks; Conglomerate rock; Mixed conglomerate and sandstone; Trap dikes; Red sandrock; and Mineral veins.

In the primary region west of Presque Isle the granite "is traversed by large and irregular dikes of greenstone trap, and the granite itself puts on a trappose character, the two rocks being sometimes with difficulty distinguishable from each other."

The metamorphic group is divided into two belts—a quartzose portion on the south, and a trappose portion on the north. The quartzose rocks are pervaded by argillaceous red and micaceous oxides of iron.

> These are frequently of so great extent as almost to entitle them to be considered as rocks. The largest extent of iron noticed is in township 47 north, range 26 west, near the corner of sections 29, 30, 31, 32. There are here two large beds or hills of ore, made up almost entirely of granulated magnetic and specular iron, with small quantities of spathose and micaceous iron. The more northerly of these hills extends in a direction nearly east and west for at least one-fourth of a mile, and has a breadth little less than 1,000 feet, the whole of which forms a single mass of ore.

This was the first discovery of the vast deposits of iron in the Marquette region at Negaunee and Ishpeming. It was in June, 1845, during a survey under the direction of Doctor Houghton, with William A. Burt as chief assistant.

"The rocks of the metamorphic group frequently graduate into clay slate." This is found in township 48, north 26 west.

Mount Houghton is the name bestowed on a knob of trap 878 feet above Lake Superior, in the southerly range of Keweenaw Point in township 58, north 29 west.

The red sandrock is in this report pronounced "the equivalent of the Potsdam red sandstone of the New York reports."

The study of the mineral veins confirms the views previously expressed by Doctor Houghton. Their courses are nearly at right angles to the line of bearing of the trap range.

In closing, Mr. Hubbard regrets the meagerness of his sketch "when compared with whatever proceeded from that master mind whose genius first developed, and whose indomitable energy tracked through all its difficulties, a system not only intricate in itself, but novel to science; and in a region at that time destitute of all the ordinary facilities for scientific investigation. To the same active and philosophic mind we owe the system of the union of geological with the lineal surveys of lands of the United States, the first experimental results of which are now returned to this department."

It may be proper to add parenthetically that the system of geologico-linear surveys was continued during the season of 1846. We find a report by William A. Burt. announcing the discovery of masses of iron ore in the Menominee district; a report by Bela Hubbard as deputy surveyor and geologist with S. W. Higgins as chief assistant; also a report by Bela Hubbard as deputy surveyor, with William Irons as assistant. These reports, 1844, 1845. and 1846. are accompanied by well engraved maps of the territory covered and work done, together with interesting views and sections illustrative of geology and scenery. The records of these surveys are contained in Annual Message and Documents 1849–50. part 3, pages 802–935; but were not published before 1850. On March 1, 1847, an act of Congress was approved, establishing "a land office in the northern part of Michigan," and Dr. Charles T. Jackson was appointed by Secretary of the Treasury Robert J. Walker to make a geological report. His report is dated Boston. November 10, 1849, and is contained in the same published volume as those of Burt and Hubbard, above cited.

Expenses.—The following is a financial statement respecting the survey from the beginning. compiled from the books of the auditor general:

Geological Survey in account with the State of Michigan.

Dr.

1837, 1838.	General purposes		$16, 026. 00
1839.	General purposes		8, 329. 95
1840.	General purposes		7, 161. 37
1841.	General purposes		6, 219. 55
			$37, 736. 87
1842.	General purposes	$1, 263. 18	
	Salary of State geologist	782. 87	
	Salary of topographer	624. 53	
	Incidental expenses	1. 032. 82	
			3, 703. 35
1843.	Salary of State geologist	1, 000. 00	
	Salary of topographer	800 00	
	Incidental expenses	220. 47	
			2, 020. 47
1844.	Salary of State geologist	1, 000. 00	
	Salary of topographer	800. 00	
	Engraving expenses	338. 16	
	Incidental expenses	397. 30	
			2, 535. 46

Geological Survey in account with the State of Michigan—Continued.

Dr.

1845. Salary of State geologist to July	$500.00	
Salary of topographer	639.42	
Engraving	658.92	
Incidental expenses	34.54	
		$1,832.88
Total payments		$47,829.03
Appropriations unexpended		4,170.97
		$52,000.00

Cr.

1837. Appropriation		$3,000.00
1838. Appropriation (Overdrawn March 1	$1,026.00)	12,000.00
1839. Appropriation (Balance March 1	2,644.00)	12,000.00
1840. Appropriation (Balance March 1	7,482.68)	12,000.00
1841. Appropriation (Balance March 1	13,263.23)	12,000.00
1842. No appropriation, balance being	9,559.78	0,000.00
1843. No appropriation, balance being	7,539.31	0,000.00
1844. For engraving, making balance	5,503.85	500.00
1845. For engraving, balance now	4,170.97	500.00
		$52,000.00

THE SURVEY AFTER 1845.

Gov. Alpheus Felch, in his annual message, dated January 6, 1846, introduces some appreciative passages respecting the geological survey, from which I present these quotations:

> The geological survey of the Lower Peninsula having been completed some time since, the final report of the State geologist upon this portion of the work, it is understood, was nearly ready at the last session of the legislature.

Then, referring to connection with the linear surveys, he continues:

> The recent melancholy dispensation of Providence in the sudden death in the midst of his labors and his usefulness of the faithful and efficient officer who has held his appointment from the first organization of the department will, it is feared, throw many difficulties in the way of making available all the valuable information acquired in the various surveys and examinations.
>
> No report of the labors of the geologist for the past season will be made to you, nor is any person authorized to complete or finish the final report on the Lower Peninsula, which is understood to be nearly prepared for the press. Many valuable engravings have been prepared for this work and much expense has already been incurred. * * *
>
> The expenses of the geological department since its organization, including the salaries of officers, amount to $50,779.02. The expenditures on the State Salt

> Springs made under the direction of the department in connection with the surveys amount to the additional sum of $33,996.93.[1]
>
> The geological surveys have abundantly developed the resources of the State and exhibited the fact that in agricultural and mineral wealth and in all the elements of true prosperity, Michigan possesses advantages excelled by no other State in the Union. The embarrassed condition of the treasury admonishes us, however, to avoid every expenditure not absolutely indispensable, and I submit to your consideration whether the duties of this department are not now so far completed as to render it expedient to bring them to a close after making the necessary provision to preserve the information already obtained.[2]

Some statements embraced in a communication from the late State topographer S. W. Higgins, dated January 7, 1846. and addressed to the legislature, ought here to be cited:

> As, in consequence of the lamented death of Doctor Houghton, late State geologist, some legislative action will be called for in relation to the future disposition of the State survey, and in the absence of the annual report from the head of that department, I have deemed it proper to accompany this report [on the sixth section lands] with some observations which may be important under present circumstances.

Mr. Higgins then proceeds to state that Mr. Bela Hubbard "had undertaken in part the preparation of the final report, for which purpose all the field notes and other information collected during the progress of the State survey were placed in his hands."

Mr. Higgins refers to the fact that the period originally contemplated for the completion of the survey expired in 1843,[3] since which time, the State geologist, under a greatly reduced appropriation, has continued actively at work, chiefly in the Upper Peninsula. He repeats the statement respecting the completion of the field work in the Lower Peninsula. He says:

> A large amount of engravings and lithographs for the final report are completed and the whole, it is thought, can be finished within another year. Most of these are in a style of art superior to anything of the kind ever executed in this country.[4]

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[1] This statement may unintentionally convey a false impression. While the location of the wells was directed by geological considerations, the sinking of them was a purely mechanical labor, which might as well have been imposed on the attorney general or the superintendent of public instruction. Nor did the money expended on the wells advance materially a knowledge of Michigan geology. This expense, instead of being coupled with geological expenditures, ought, so far as the State geologist's time devoted to well boring is concerned, to be deducted from the aggregate expenses of the survey. The same is true of expenses incurred in making collections for the university in locating sixteenth section lands and in running the boundary between Michigan and Wisconsin.

[2] It would appear that the governor had power, if he would, to appoint a successor to Doctor Houghton. Had he done this the machinery would not have fallen to pieces.

[3] It appears to have expired Mar. 1, 1842, the last appropriation being available Mar. 1, 1841. The most obvious interpretation of the law would make the last appropriation available Mar. 1, 1840.

[4] It is greatly to be regretted that these illustrations could not have been permitted to see the light. I came into the State but eight years after the date of this communication, but have never been able to discover the place of deposit of these drawings and engravings. I found the tradition in existence as above stated; and I think the impression prevails that this class of property was placed in the custody of the university. But

The whole subject as set forth in the governor's message and the communication of the State topographer was referred to a select joint committee and their report constitutes document No. 15 of the session of 1846. They present a concise and admirable sketch of the history of the survey and of its progress and results. Their statements are appreciative and cordial and show that the labors and difficulties of the work have been duly considered. Since 1842, they say, no officers in the geological department have been continued in active employment except the geologist and topographer, and they at greatly reduced salaries. They state that the total amount expended is \$32,829.03, which falls short of the amount appropriated \$7,170.97.[1] Placing a value of \$8,000 on the material which has gone into the university, there is left \$24,829.03 "as the entire cost of the survey to the State. This is enough to have constructed 2 miles of railroad."[2]

The committee describe the collections made; the work done toward the completion of maps, the very superior character of the data and the workmanship, and give a statement of the unfinished work. They embody a strong indorsement of the plan of combining linear and geological surveys. Speaking of the character of the materials belonging to the department, they enumerate "very voluminous collections of notes, maps, diagrams, engravings, etc. A wall map of the State and maps of 15 counties are in the hands of an engraver, and, in addition to the four already published others are nearly if not quite completed, and their reception has been delayed only by the failure of the engraver to fulfill his contract. To execute the engravings for the final report, the services of a wood engraver of great reputation and skill have been secured. These have been cut by him from drawings by the State topographer. In addition to these are many lithographs executed on stone by the latter officer; and it may be said, without exaggeration, that all these are in a style of art far superior to any that have ever been produced to illustrate a work of the kind in this country. More than two-thirds of all these are now finished."

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such appears not to have been the fact. In January, 1871, in searching the archives of the State capitol I discovered, in some drawer, buried in dust and miscellaneous papers, two or three blocks with well-executed drawings, apparently intended for the engraver. These are now in the university museum. Possibly the remaining drawings and engravings are preserved in the capitol. It is also not improbable that drawings not completely engraved, or engravings not paid for, remained with the engravers; but I find it nowhere stated who were the engravers, though a tradition exists that they resided in Buffalo [Winchell].

[1] I deduce different results as shown in the exhibit already introduced. This committee makes an error in footing up the debits of the survey, and in the credits they do not include any appropriation for 1841. Compare also Governor Felch's statements [Winchell].

[2] The force of this is denied from the fact that the State was impoverishing itself in spending hundreds of thousands of borrowed money in building railroads.

The committee close by earnestly recommending the continuance of the present organization of the survey, and the appropriation of $1,000 for the salary of the State geologist, $800 for the State topographer, and $500 for the completion of the engravings for the final report and incidental expenses. The report is signed by J. N. Chipman, chairman senate committee, and G. W. Peck, chairman house committee.

A general impression had begun to prevail that the Northern Peninsula of Michigan was the repository of valuable amounts of copper and iron. Adventurers and capitalists were turning their attention to the region and some leases had been made under authority of the United States. Accordingly, on the 25th of April, 1846, a resolution passed by the legislature of Michigan was approved declaring that the title to all mines of gold, silver, and other metals is vested in the State except on lands owned by individuals and such lands as the General Government had reserved from sale; and providing also for the taxation of ores.

On the 15th of May, 1846, the legislature adopted a joint resolution authorizing the governor to "appoint some competent and suitable person to collect, collate, and arrange all the geological notes, memoranda, specimens, maps, topographical delineations, engravings, barometrical and other observations, including geological surveys, kept, taken, made, collected, and preserved for and in behalf of the State of Michigan by the late Dr. Douglass Houghton, State geologist, and designed and intended by him to be used in making a final geological report for the benefit of the people of said State; and from the material thus collected and to be collected, and the requisite additional information derived from other sources, the person thus to be appointed may be required by the governor to prepare a final report upon the geology of Michigan."[1]

I have not learned that any action was ever taken under this law. One can not help feeling that the government of Michigan committed a crime against the people and against posterity, to allow the vast store of records, results, traditions, and personal recollections then extant, to lie unappreciated and pass to decay and oblivion. Bela Hubbard was entirely competent to do justice to the demand, and Mr. Higgins was master of the topographical problems. Mr. C. C. Douglass was even now at work as a mining expert in the Upper Peninsula, and many others were in possession of personal knowledge which might have been made available. It must have been a painful experience of those geologists to see the products of years of toil and aspiration perishing before their eyes, while they sent up unavailing cries to a narrow and parsimonious legislature to rescue them for the credit and benefit of the State.

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[1] Laws of Michigan, 1846, p. 314.

By a joint resolution adopted April 7, 1846, all the collections by the late geological survey were transferred to the university. This provision was also embodied in an act approved May 11, 1846. The university is also in possession of standard works on geology and paleontology, which appear to have been once the property of the survey or of Doctor Houghton. What amount was expended by the survey in the purchase of books does not appear from accessible records, but I find a joint resolution, adopted February 12, 1841. authorizing the State geologist to pay Collins, Keese, and Company, of New York, a balance of $664.50 due for books ordered by Governor Mason in 1837 and 1838.

The geological researches instigated and conducted by Doctor Houghton have proved of great importance both directly and indirectly in the growth of the State. The geologists were, in both peninsulas, explorers of a wilderness, and first promulgators of reliable information concerning everything which makes a State desirable or undesirable for settlement and enterprise. In the Lower Peninsula they established the existence of extensive deposits of coal, gypsum, and building stones, and awakened an interest and confidence in the existence of copious supplies of brine, which were not dispelled by the qualified failures at the two State wells and Lyon's well at Grand Rapids, but survived until, under more favorable financial auspices, investigations were reinaugurated and crowned with marvelous success. Extensive deposits of kidney iron ore were disclosed, and for their working, the Union City Iron Company was incorporated March 17, 1847. The Saginaw Gypsum Company was incorporated March 28, 1849.

In the northern peninsula, enterprise was awakened which continued to enlarge with the progress of development, until Michigan has assumed a leading position in the production of copper and iron. The Pioneer Smelting Company of the Upper Peninsula of Michigan was incorporated by the legislature March 16, 1847. The Copper Falls Mining Company was incorporated March 16, 1848, and on the same date acts of incorporation were approved for the Northwestern Mining Company and several others. During the session of 1848, 23 mining companies were incorporated. Jacob Houghton, jr., gives a list of 102 mining companies in the Lake Superior region to July 17. 1846. To the same date he enumerates about 900 locations. leases, and permits dating from May 13, 1844, and subsequently.[1] The tide of mining enterprise was now setting strongly. With what failures and successes this industry had been prosecuted is known to

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[1] Mineral Region of Lake Superior, pp. 147–191.

ALEXANDER WINCHELL

STATE GEOLOGIST OF MICHIGAN, 1859-61 AND 1869-71.

the world. Whatever wealth has accrued to individuals or to the State, whatever renown has come to the State as one of the world's chief centers in metallic production, whatever impulse has been felt in the progress of settlement and improvement of a remote northern section, all springs originally from the genius which planned the first geological survey, and the energy which conducted it in the face of formidable obstacles and under depressing financial circumstances during nine laborious years.

SECOND SURVEY UNDER THE DIRECTION OF ALEXANDER WINCHELL, 1859-1860 AND 1869-1871.

The first geological survey of Michigan expired by limitation in 1842; but Dr. Houghton was officially recognized as State geologist during 1843, and some moderate expenditures were incurred under official sanction. But in 1844 the State geologist had entered into a contract with the General Government for prosecuting geological explorations in the Upper Peninsula, in connection with the linear surveys. The work was continued for one year after Doctor Houghton's death in October, 1845, when a separate geological survey was instituted by authority of Congress; and this was continued under the directorship of Dr. C. T. Jackson during 1847 and 1848 and of Messrs. Foster and Whitney during 1849 and 1850.

THE GEOLOGICAL SURVEY IN 1859.

On the establishment of a separate chair of geology, zoology, and botany in the university, in 1855, and the appointment thereto of Alexander Winchell, attention was again turned to the subject of a State geological survey. No definite action, however, was undertaken until 1857, when a few petitions for the reinauguration of the survey were presented to the legislature, and a bill was introduced, which failed to pass. When the legislature of 1859 convened, 16 years had passed since the State had suffered its survey to fail; and it was eight years since official work had ceased in the rapidly developing regions of Lake Superior. Both the recent progress of industrial development and the improved financial condition of the State prompted to the reorganization of the geological survey. Accordingly, during the legislative session of 1859, petitions were numerously addressed to the legislature, calling for a renewal of geological work. These were referred, in the House of Representatives, to a committee who called on Prof. Alexander Winchell for a presentation of the public benefits anticipated from a survey. These were communicated with some fullness.[1] A bill was passed which received the signature of Gov. Moses Wisner, February 15, 1859.

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[1] House Document No. 29, Legislature of 1859, p. 10.

The following is the text of this bill, and those passed subsequently with reference to this survey:

An act to finish the geological survey of the State.

SECTION 1. *The People of the State of Michigan enact*, That the governor is hereby authorized and directed to appoint a competent person, whose duty it shall be to finish the geological survey of this State, which shall be accompanied with proper maps and diagrams, and shall furnish a full and scientific description of its rocks, soils, and minerals, and of its botanical and natural productions, together with specimens of the same; which maps, diagrams, and specimens shall be deposited in the library of the State University and the library of the Agricultural College, and similar specimens shall be deposited in such other library (literary) and scientific institutions of the State as the governor shall direct. And the governor is further authorized to appoint, from time to time, as the exigencies of the case may require, competent persons to act as assistants, under the direction of the geologist.

SEC. 2. A sum not exceeding $2,000 for the year A. D. 1859, and a sum not exceeding $3,000 for the year 1860, is hereby appropriated to defray the expenses that may be incurred under the act, which sums shall be paid out of the treasury, from any money not otherwise appropriated, at such times and in such sums as the governor may direct; and an account of all the expenditures of each year shall be reported to the legislature in the same manner as is now required by law of the State officers.

SEC. 3. The geologist appointed by the governor shall make a report to the legislature, whenever the same is in session, setting forth generally the progress made in the survey hereby authorized.

Approved February 15, 1859.

An act to provide for the further geological survey of the State.

SECTION 1. *The People of the State of Michigan enact*, That the governor, the superintendent of public instruction, and the president of the State board of education shall constitute a board of geological survey; they shall control and supervise the continuance and completion of a geological survey of the State; they shall appoint and commission a suitable person, possessed of the requisite knowledge of the science of geology, who shall be the director of the geological survey hereby instituted.

SEC. 2. Such director shall have the power to appoint, by and with the advice and consent of the board, such assistants as may be necessary to perform the labor herein directed.

SEC. 3. The salary of the director, and of all other persons employed in the survey, shall be fixed by the board, and shall be payable only for services actually rendered; such board shall regulate all expenses incident to the survey and may require from the director such frequent reports as they may think useful.

SEC. 4. It shall be the duty of the director to make, or cause to be made, a thorough geological and mineralogical survey of the State, embracing a determination of the succession, arrangement, thickness, and position of all strata and rocks; their mineral character and contents and their economical uses; an investigation and determination of the organic remains of the State; a general examination of the topography, hydrography, and physical geography of the State; an investigation of the soils and subsoils, and the determination of their character and agricultural adaptation; the investigation of all deposits of brines, coal, marl, clay, gypsum, lime, petroleum, metals, and metallic ores, building stone, marble, gritstone, materials for mortar and cement, mineral paint, and all other productions of the geological world within the limits of this State capable of being converted to the uses of man.

SEC. 5. It shall be the duty of the director to collect ample materials for the illustration of every department of geology and mineralogy of the State and to determine, catalogue and label the same, and prepare them for exhibition to the citizens of the State in suitable cases in the museums of the State University and State Agricultural College, and the State Normal School, and such other colleges of the State as may make application to the board prior to the taking of the geological survey, and obligate such college to pay the extra expense necessarily incurred in furnishing such specimens.

SEC. 6. It shall be the duty of the director to furnish annually to the board a report of the progress of the survey, and as often as possible a condensed statement of important and interesting facts for general circulation, and, as soon as the progress of the work will permit, to begin, and on the completion of the survey to finish a complete memoir upon the geology of the State, under the direction of the board, embracing such an account of all its mineral and agricultural resources as is usual in works of that character, and a delineation of its geology upon the map of the State and such other diagrams and illustrations as may be needed to set forth in a creditable, intelligible, and as far as possible popular manner the nature, location, and extent of the geological and agricultural resources of the State.

SEC. 7. The one-half part of all appropriations made shall be expended in the Upper Peninsula, and such one-half shall be devoted, among other things, to the collection of statistics and history of the mineral, manufacturing, and transportation interests; to the compilation and preparation of full and accurate maps showing the topography, geology, and timber, as also the position of mines, furnaces, roads, and improvements; to the determination of the position and structure of the minerals and mineral rocks; to compiling and collecting all useful knowledge that would be of practical value in finding and extracting ores, and in mining and smelting in those districts of the Upper Peninsula known as the iron and copper regions.

SEC. 8. All notes, memoranda, compilations, collections, specimens, diagrams, and illustrations that may be made in the progress of such survey by the persons engaged therein shall be the property of the State; shall be under the control of the board and, in case of the death or termination of connection with such survey of any such person, shall be deposited in the State University, subject to the order of the board.

SEC. 9. To carry into effect the provisions of this act the sum of $8,000 for each year is hereby appropriated, to be drawn from the treasury as needed, on the warrants of the governor, which appropriation shall be in full for all expenditures under this act, exclusive of the printing of the reports hereby provided for.

SEC. 10. This act shall take immediate effect.

Approved March 26, 1869.

Joint resolution asking an appropriation to aid the geological survey of this State.

Whereas the State of Michigan has, by a recent act of her legislature, appropriated the sum of $8,000 for a geological survey of the State;

And whereas the United States are largely interested in the rapid development of the well-known mineral resources of the Upper Peninsula, having yet unsold, in that portion of the State, a large area of mineral land: Thereupon, be it

Resolved by the Senate and the House of Represensatives of the State of Michigan, That our Senators are hereby instructed and our Representatives requested to ask of the Congress of the United States such annual appropriations, not less than $8,000, for a period of three years, to aid in such survey, as the interest and propriety of the United States, within the limits of the State of Michigan, would seem to justify and require.

Resolved, That the governor be requested to transmit copies of the foregoing preamble and resolutions to each of our Senators and Representatives in Congress.

Approved March 30, 1869.

An act to amend sections 1, 3, 4, 5, 6, 8, and 9, and repeal sections 2 and 7 of an act entitled "An act to provide for the further geological survey of the State," approved March 26, 1869.

SECTION 1. *The People of the State of Michigan enact,* That sections 1, 3, 4, 5, 6, 8, and 9 of an act entitled "An act to provide for the further geological survey of the State," approved March 26, 1869, be amended as to read as follows:

SECTION 1. *The People of the State of Michigan enact,* That the governor, superintendent of public instruction, and the president of the State board of education shall constitute a board of geological survey. They shall control and supervise the continuance and completion of the geological survey of the State; and for that purpose they may from time to time appoint such person or persons to assist in making said survey as may be deemed necessary; the length of time and the location and locations where said persons shall be employed shall be determined by said board.

SEC. 3. The salary of the persons employed in the survey shall be fixed by the board, and shall be payable only for services actually rendered. Such board shall regulate all expenses incident to the survey, and may require such frequent reports as they may think useful.

SEC. 4. It shall be the duty of said board to make, or cause to be made, a thorough geological and mineralogical survey of the State, embracing a determination of the succession and arrangement, thickness, and position of all strata and rocks, their mineral character and contents and their economical uses; an investigation of soils and subsoils, and the determination of their character and agricultural adaptation; the investigation of all deposits of brines, coal, marl, clay, gypsum, lime, petroleum, and metals and metallic ores, building stone, marble, gritstone, materials for mortar and cement, mineral paint, and all other productions of the geological world within the limits of this State capable of being converted to the uses of man.

SEC. 5. It shall be the duty of said board to cause ample materials to be collected for the illustration of every department of the geology and mineralogy of the State, and to label, arrange, and prepare the same for exhibition in suitable cases in the museums of the State University, Agricultural College, and State Normal School, and in each of the incorporated colleges of the State, and in a room in connection with the State library.

SEC. 6. It shall be the duty of said board to furnish an annual report of the progress of the survey and, as often as possible, a condensed statement of the important and interesting facts for general circulation, and as soon as the progress of the work will permit to begin, and on the completion of the survey to finish a complete memoir upon the geology of the State, embracing such an account of all its mineral and agricultural resources as is usual in works of that character, and a delineation of its geology upon the map of the State, and such other diagrams and illustrations as may be needed to set forth in a creditable, intelligent, and, as far as possible, popular manner the nature, location, and extent of the geological and agricultural resources of the State: *Provided*, Such report when complete and printed shall consist of not exceeding three octavo volumes: *And provided further*, That said volumes shall not contain in any considerable extent compilations and extracts of or from books heretofore published.

SEC. 8. All notes, memoranda, compilations, collections, specimens, diagrams, and illustrations that may be made in the progress of such survey by the person or persons engaged therein shall be the property of the State, shall be under the control of the board, and in case of the death or termination of connection with such survey of any person or persons, shall be deposited in the office of the superintendent of public instruction, subject to the order of the board.

SEC. 9. To carry into effect the provisions of this act the sum of $8,000 is hereby appropriated for each year until the completion of said survey, to be drawn from the treasury as needed on the warrants of the governor, which appropriation shall be in full for all expenditures under this act, exclusive of the printing of the reports.

SEC. 2. Sections 2 and 7 of an act entitled "An act to provide for the further geological survey of the State," approved March 26, 1869, are hereby repealed.

SEC. 3. This act shall take effect immediately.

Approved April 17, 1871.

Administration.—Under the law of 1859 Alexander Winchell, professor of geology, zoology, and botany in the University of Michigan, was duly commissioned by Governor Wisner to perform the duties of "State geologist." His commission bore date of March 9, 1859. On consultation with the governor respecting a plan of operation it was agreed that the intent of the joint resolution appropriating a sum of money for the publication of unpublished results of the former survey would be legally fulfilled by consolidating those results, if any, with the results of the new survey, giving due credit for all the old matter, and employing the appropriation in the prosecution of the general work. Under this arrangement the new survey was provided with $3,000 for 1859, as well as $3,000 for 1860. This, however, was sadly incommensurate with the breadth of the law's requirements and permitted only a very meager organization.

Under the plan agreed upon the State geologist was to spend six months of the year in the field at a salary of $1,000. He was to have one chief assistant, who should spend the same amount of time in field work, and receive a salary of $750. Ostensibly no salaries were to be paid for office work. The State geologist was to direct his efforts specially to geological investigations, but was to make zoological collections incidentally. The assistant was to direct his efforts specially to zoological investigations, but was to make geological collections incidentally. Each was authorized to employ a subassistant. In working up the various departments it was anticipated that the volunteer services of scientific experts could be secured, to a reasonable extent, for the privilege of retaining examples of new and rare species. The personnel of the corps was thus constituted as follows: Alexander Winchell, State geologist, $1,000; Manly Miles, assistant, in charge of zoology, $750; Albert D. White, subassistant to the State geologist, expenses; E. Doge, taxidermist and laborer, expenses and $1 a day.

Collaborators engaged: Prof. Abram Sager, Ann Arbor, arachnida, myriapoda, and crustacea; J. L. LeConte, Philadelphia, coleoptera.

Volunteer collectors: J. H. Goodsell, Pontiac; N. H. Winchell, Ann Arbor, botany; E. E. Baldwin, Ann Arbor, botany; E. P. Austin, of Lake Suney, entomology.

The State geologist began field work by spending a week at the fishing station of George Clark on the Maumee River, where two barrels of fishes were preserved in alcohol, embracing all the forms captured in the fishing nets, as also several skins of the larger species, and about a bushel of Unionidae, most of which were preserved with the animals in alcohol.

In entering upon the geological work it was deemed advisable to make a fresh reconnoissance of all parts of the State. Since the close of the field work in the Lower Peninsula, in 1840, the opportunities for observation had been much increased, and the methods of geological investigation had become more exact and in other respects improved. It was necessary, furthermore, that a geologist new to the field should make a personal acquaintance with it preliminarily. Accordingly, the requisites were procured for travel by private conveyance and for camping. On May 18, the State geologist set out with his assistant to begin work in Monroe County. Doctor Miles, meantime, was occupied in studying the ornithology of the Saginaw River and Bay, with the aid of an india-rubber boat, a camp outfit, and an assistant.

The geological reconnoissance extended during the season over the larger part of the four southern tiers of counties of the State and detailed studies were made at all the principal rock exposures, particularly in Monroe, Hillsdale, Eaton, Jackson, and Kent counties. At times, for the purpose of expediting the work, Mr. White traveled alone by private conveyance over a region with few outcrops, and the State geologist visited important points accessible by the public conveyances, the various railroad companies pursuing at that time, though heavily taxed by the State, a very liberal policy toward the State survey. Doctor Miles, after spending some time on the Flint and Saginaw Rivers, traversed Oakland, Washtenaw, and

Livingston counties, and late in the season visited the western part of the State.

A printed circular, addressed to the county surveyors of the State and dated September 1, 1859, called upon them for the contribution of topographical facts. Several valuable responses were received, and others were put in course of preparation by the end of the year.

One of the most important and fruitful determinations made during the season of 1859 was the identification of the fossiliferous sandstone of Ottawa County with the sandstone of Hillsdale County. This determination was made August 24, and was the occasion of a radical change in the conceptions entertained of this stratigraphical structure underlying the southern peninsula. It revealed a reappearance along the southern border of the Peninsula of strata which on the southeast had been seen to dip toward the interior and disappear. It was the first inductive demonstration of that dishlike conformation which is now so well understood. But the evidence of this, of course, was not yet complete. This identification placed the limestones and gypseous deposits of Kent County in a new light, and changed fundamentally the theoretical position of the brine-bearing strata. The first application of these views was made October 29, 1859, in an official communication addressed by James Scribner, of Grand Rapids, who placed it at the disposal of the city newspapers. The following are some passages from this communication:

> The salt-and-gypsum-bearing formation seems to be a deposit intercalated between the limestone of Grand Rapids and the Napoleon series of sandstones. The salt springs of Kent county occur at the outcrop of the saliferous rocks. * * * These pass under the city of Grand Rapids, and it is quite possible they form a continuous deposit, underlying the central part of the State, and reappearing on the east shore of Saginaw County. * * * The strongest brine would naturally be found at the lowest point of a salt basin, and the weakest near the outcrop. The well which you have bored (at Coldbrook, a suburb of Grand Rapids on the northeast) is consequently more favorably situated than if farther toward the southwest; and there is a probability of procuring still stronger brine by boring still farther toward the north or northeast, although, from the dip of the rocks, the salt-bearing deposit would be found more deeply seated at Coldbrook.
>
> In reference to your question as to boring deeper in your present well (258 feet deep), I would say, decidedly, no. The geological structure of the region shows that you have gone to the bottom of the salt-bearing rock. The underlying standstone outcrops in the bed of the river half a mile above Grandville; and there is danger that in penetrating this, you will strike a vein of fresh water and lose all you have gained, etc.

Since the failure of the salt enterprise in 1838-1842, the belief had never been wholly dispelled that somewhere in the rocks of the State valuable supplies of brine were held. There were many intelligent people who felt that further experiments ought to be made, though it was reasonable that the expense should fall upon the public treasury. This surviving confidence in the salt resources of the State found expression in 1857 in the petitions for a renewal of the geological survey, and clearly entered into the motives which led to the reorganization of 1859. More direct aid was also sought. Grand Rapids and the Saginaw Valley, as being the sites of the early experiments, were naturally centers of active interest in salt enterprise. At the former place, James Scribner, in 1858, had induced the board of supervisors of Kent County to adopt a petition to the legislature for the enactment of a law granting a bounty on all salt manufactured in the State. Petitions were circulated and a bill was introduced and passed by the legislature in 1859. In the Saginaw Valley the influence of Dr. George A. Lathrop was strongly exerted in favor of the bill; and the power of the press was conspicuously illustrated by the advocacy of Henry Barns, Editor of the Detroit *Tribune*. Mr. Barns was a man of broad intelligence and deeply concerned in the development of the material interests of the State. The geological survey felt the benefit of his influence, and his name deserves to be commemorated. The bounty law was enacted almost simultaneously with that reviving the geological survey. It granted 10 cents a bushel for all salt manufactured in the State after the production of 5,000 bushels, and exempted from taxation all property employed in the business.

Under the stimulus of the bounty, the East Saginaw Salt Manufacturing Company was organized in April, 1859, and began boring in June.

The Grand Rapids Salt Manufacturing Company, with James Scribner as president, also began boring August 12, 1859. The enterprise at Grand Rapids was prompted by the proximity of the partially successful well bored by Lucius Lyon in 1840, while one of the Houghton State wells, also, was distant only 4 miles.

The progress of observations under the geological survey soon enabled the director to offer valuable suggestions in connection with these explorations for salt. It was in compliance with one of the requests for advice that the opinions were drawn up which have already been cited in reference to the salt formation at Grand Rapids. A geological visit was paid November 10, to East Saginaw. The well was then down 445 feet, and Doctor Lathrop submitted for examination a complete series of rock samples brought up. Comparing these with the rocks already studied at their outcrops on three sides of the Peninsula, the State geologist was able to detect a satisfactory correspondence, and announced that the bottom of the Marshall sandstone, at present known as the reservoir of the brine, would be reached at about 800 feet, and that there would be no need of continuing to a greater depth unless it were decided to penetrate to the Onondaga salt formation. On the 11th of February, 1860, a similar series of well borings at Grand Rapids, reaching to the depth of 490 feet, was submitted to the State geologist for examination. These had been preserved by A. O. Currier, R. E. Butterworth, and Martin Metcalf. On this occasion the State geologist delivered a public address in Lyceum Hall, in which he set forth, with greater fullness than before, his conception of the geological relations of Michigan brines.

On February 7 the East Saginaw Salt Manufacturing Company presented a formal report, in which their enterprise was pronounced a complete success. The hole was 3⅝ inches in diameter, and had been sunken to a depth of 640 feet. at which point the brine obtained lacked over 10 salometer degrees of saturation. This well was subsequently extended to 669 feet, reaching brine within 6° of saturation; and a subsequent larger well was carried to a depth of 806 feet, passing quite through the Marshall sandstone. This was the point which the State geologist had previously fixed at about 800 feet.

On February 16, 1860, the Saginaw *Enterprise* published a report from the State geologist which had been addressed to Dr. H. C. Potter, one of the directors of the East Saginaw Salt Manufacturing Company.[1] In this, an attempt was made to correlate the geology of the well borings at Grand Rapids and Saginaw with the observed geology of the State as studied at the outcrops. It supplied the first published statement of the stratigraphy of the lower peninsula under the conceptions which had been based on the observations of 1859. As a historical memorandum it seems to be worthy of reproduction in this sketch.

Rock Formations as Observed in 1859.

I. CARBONIFEROUS SYSTEM.

1. Coal measures, consisting of—
   (*a*) Woodville sandstone (the "overlying" sandstone).
   (*b*) Shale, coal, fire clays, sandstones, ironstone, etc.
   (*c*) Parma sandstone.
   (*d*) Cherty sandstone (probaby the coal "Conglomerate").
2. Carboniferous limestone:
   (*a*) Upper (not seen south of Grand Rapids).
   (*b*) Red, arenaceous limestone, 5 feet.
   (*c*) Lower (Grand Rapids, Bellevue, Parma, Spring Arbor, etc.).
3. Gypseous series (shales, clay, cherty limestone, gypsum, salt).
4. Napoleon series, consisting of—
   (*a*) Napoleon sandstone.
   (*b*) Striped sandstone.
   (*c*) Ironstone (not universal), 4 inches.

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[1] This was also included in the report of the directors to the stockholders.

II. DEVONIAN SYSTEM.

5. Marshall series (Hillsdale, Jonesville, Marshall, Battle Creek, Holland, Point aux Barques, etc.).
   (*a*) Marshall sandstone.
   (*b*) Shaly micaceous sandstone.
6. Shale, abounding in kidney iron ore.
7. Monroe limestone.

An interpretation was now for the first time placed on the facts obtained in the State salt well and Lyon's well at Grand Rapids. As this report announced:

> The State well commenced in the lower part of the Gypseous series. It struck the Napoleon series at 61 feet, the Marshall series at 184 feet, and the shale series at 343 feet, which it penetrated 130 feet. The boring at Lyon's well commenced in the Carboniferous limestone, which was here 19 feet thick. It struck the Gypseous series at 20 feet, the Napoleon series at 191 feet, the Marshall series at 309 feet, the shale series at 446 feet, and continued in this 214 feet. The boring at Saginaw, after passing through a great thickness of alluvial and diluvial materials, struck upon the Woodville sandstone at 92 feet, the shales, etc., of the coal measures, at 171 feet, the Parma sandstone at 294 feet, the Carboniferous limestone at 399 feet, the gypseous series at 464 feet, and the Napoleon series at 633 feet.
>
> Judging from the experience at Grand Rapids and from my observations on the outcrops of the lower rocks, you will next find 250 to 300 feet of arenaceous rocks and then over 200 feet of shales. You will not discover as strong brine at any point lower than this which will overflow at the top. We must, probably, content ourselves in this State with raising the salt water by pumps. * * * I believe * * * the superior strength of your brine, the comparative cheapness of fuel, and your location upon navigable waters which stretch many hundred miles in every quarter to the west of your meridian, as well as to the east of it, will enable you to compete with any other source of supply to the Northwestern States.

In a report to the governor on the operations and results of the year 1859 the State geologist, under date of April 9, 1860, embodied an exhibit of the stratigraphical structure of the Lower Peninsula substantially identical with that already cited. For that reason it is not necessary to reproduce it here. The same interpretation was put upon the geology of the salt wells. It will be understood, therefore, that the order of stratigraphical successions first formulated in February, 1860, and standing materially unchanged to the present time, was the result of studies made in 1859. It was not yet, however, fully understood that the salt group, on account of its shaly constitution, could not hold supplies of brine within itself, but the underlying Napoleon and Marshall sandstones must serve as reservoirs of the brine. That conception, however, was foreshadowed, since in his report to the East Saginaw Salt Manufacturing Company, the State geologist, speaking of the arenaceous rocks and shales beneath the bottom of the well, as it was on February 7, said: "I have some reason for believing that this entire series is somewhat saliferous." Also, in his report to the governor in April, 1860, he said the sandstones below the salt group yielded the principal volume of brine at East Saginaw. The following passage from the same report is an interesting illustration of the value of scientific judgments in relation to industrial enterprises:

> Near the close of the season (November, 1859), I visited Saginaw County with special reference to the prospect of obtaining salt in that vicinity. After having become acquainted with the geological succession in other parts of the State I was enabled to predict with great confidence the depth at which the saliferous stratum would be pierced, and I have the satisfaction of knowing that salt was found within two feet of the depth which I had foretold.

THE GEOLOGICAL SURVEY IN 1860.

In extending a general reconnoissance over the northern portion of the Lower Peninsula the increased expense of outfit and transportation led to a consolidation of the workers in one traveling party. After an examination of the valley of the Cass River all expenses of the survey were disbursed directly by the State geologist. The consolidated party now proceeded by Mackinac coast to an exploration of the lake shores. From the mouth of the Saginaw River they coasted eastward to the vicinity of Forestville. Then, returning to the mouth of the river, the survey was extended to all the coasts of the mainland and islands as far as Cockburn's Island on the east, Lake Superior on the north, and Northport, in Grand Traverse Bay on the west.

Administration.—The following was the field staff for 1860: Alexander Winchell, State geologist, $1,000; Manly Miles, assistant, $750; Albert D. White, subassistant, $30 a month; Newton H. Winchell, subassistant, $30 a month; two voyageurs, each, $30 a month.

The geological survey made an exhibit of economic minerals at the State agricultural fair at Detroit, in September. Geologists who have taken a hand in such exhibitions will understand how large a waste of time they involve.

After the close of the field work for the season attention was directed to the elaboration of reports. The disturbed condition of the country created a presentiment that years would elapse before another report would appear, and the State geologist determined therefore to draw up a concise general summary of results attained. With his characteristic enterprise, Mr. Henry Barns of the Detroit *Tribune* sought and obtained, in advance of publication, a digest of the contents of this report, so far as they related to the industrial interests of the State. As the public printers did not present the complete report for general use, until November 1, 1861, the advance publications of the Detroit *Tribune*[1] secured a priority of over 10 months. The synoptical table of the rocks of the Lower Peninsula published at this date, was almost identical with that reproduced from the report on a subsequent page of this sketch. The following views were embodied in the same digest:

> From the Potsdam sandstone to the close of the upper Helderberg period, the geology of our State corresponds well with that of New York and other States. From the close of the Helderberg period, Michigan seems to have had a history somewhat special to itself. We have here a basin which at very remote periods was isolated from the seas which transported the sediments of surrounding States.

In this connection facts were cited pointing to the northern origin of the sedimentary materials.

Benefits.—Economically the most important discovery made during the season of 1860 was the existence of a great gypsum formation within an elevated ridge nearly parallel with the shore of Lake Huron, and approaching nearest at a point about four miles south of Tawas. This was identified with the gypsum formation west of Grand Rapids. The inference was thus drawn that a continuous bed of gypseous materials underlaid all the central part of the Peninsula; and this opened the way to new views respecting the origin of gypsum. This bed was not actually exposed in this vicinity till some years afterward; and in the meantime, it was maintained by men priding themselves as "practical," in opposition to theorizing geologists, that the ridge contained no gypsum, and that the only gypsum on the eastern slope of the State was at Whitestone Point, six miles further south, at the water level and beneath it. Here, in 1841, several tracts had been entered by McDonald, an Indian trader. "He and hundreds of others," as tradition holds, "searched vigorously, but found nothing above water." The deposit now brought to light has become one of the State's great resources.

Publications.—The First Biennial Report of the Progress of the Geological Survey was presented to the governor, and by him to the legislature, on the 31st of December, 1860. Of this the legislature ordered printed 5,000 copies. To the State geologist for distribution were allotted 500 copies, and to the assistant in zoology, 200 copies; to each member of the legislature one copy, and for distribution by the legislature, 2,000 additional copies stitched in paper. The printing and binding of the report were not completed until November 16, 1861. It forms an octavo volume of 339 pages, and embraces observations on the geology, zoology, and botany of the Lower Peninsula. An "introduction" of 13 pages on the History of Geology in Michigan is occupied chiefly with an account of work under the direction of Doctor Houghton, and brings together a connected statement of the "Succession of Strata in Michigan as published in 1838–1841."

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[1] It should be said that the Detroit *Free Press* and the Detroit *Advertiser* published quite extensive extracts and abstracts from the forthcoming report.

The definite exhibit of the geological succession in the Lower Peninsula of Michigan had never been enunciated before the results of 1859–1861 were attained.

> The Carboniferous limestone had never before been identified in the State, but had generally been confounded with the Monroe and Mackinac limestones. The Michigan salt group was a totally new and previously unsuspected formation. * * * The fact that the formation underlies all the central part of the State was not only unsuspected, but was a fact out of harmony with the theory then prevailing respecting the origin of gypseous deposits. Geologists generally had held gypsum to be a secondary product, resulting from chemical reactions in the rocks, and especially from the action of sulphuric acid on limestones and dolomites. The conception of a continuous gypsum formation having a sedimentary origin, had probably seldom if ever been entertained.[1]

That view resulted from researches made in Michigan in 1859–60, and at this day scarcely any other finds defenders. Salt basins, therefore, are the sites of ancient areas of salt water which have gradually dried up.

Before these investigations the gypsum of Mackinac and Grand Rapids had been regarded as of one geological age. It was now shown that the Mackinac gypsum is of the age of that in central New York and on Sandusky Bay. It followed that the whole peninsula is underlaid by a second and deeper salt basin—the Salina formation—and that quite probably this basin would also be found a source of brine supplies.

The report showed that the salt springs of the Peninsula follow especially the lines of the outcrop of the principal salt basin, and mark the geological boundary of the formation. It showed that the area of the Peninsula had never been subjected to disturbing agencies; hence the strata were but little fissured, and few opportunities existed for the ascent of the brine from deep underlying formations. It raised the query how brine, which is heavier than water, should be made to ascend, as had heretofore been assumed possible, several hundred feet through fissures accessible to shallower fresh waters, even if such fissures existed, and showed that, of necessity, the undiluted brine from any deep-seated formation must be pumped up; and that if salt water overflows at an artesian boring, it results simply from a head of fresh water mingled with some accidental supply of brine. It showed that the marginal salt springs of the State are simply drippings from the salt-bearing formations, prompted by the descent of fresh waters into them, and greatly diluted by rains falling near the locations of the springs. It showed that the salt springs of Michigan which had been the object of so much exploration, legislation and expenditure, possess no importance, except as "licks" for wild animals, and that the 72 sections of "salt spring lands" patented to the State never possessed any value above that of ordinary agricultural lands.[1]

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[1] Winchell, Sparks from a Geologist's Hammer, pp. 268, 269.

Financial statement for 1859–1860.

Resources, 1859.

Appropriation for survey for 1859		$2,000.00
Appropriation to publish former unpublished reports, if any		1,000.00
Total available for 1859		$3,000.00

Expenditures, 1859.

Salary of State geologist	$1,000.00	
Salary of assistant in zoology	750.00	
		$1,750.00
Incidental expenditures for geology		709.22
Incidental expenditures for zoology—		
Claims presented during 1859	$540.78	
Claims filed and paid May 18, 1860, for expenses in 1859	94.58	
		635.36
		$3,094.58
Geological property on hand	$208.00	
Zoological property on hand	68.00	
	$276.00	
Incidental expenditures 1859, less property on hand—		
Geological		$501.22
Zoological		567.36

Resources, 1860.

Appropriation for survey in 1860	$3,000.00

Expenditures, 1860.

Salary of State geologist	$1,000.00	
Salary of assistant in zoology	750.00	
		$1,750.00
Paid for subassistants, voyageurs, and all incidentals		1,250.00
		$3,000.00

A claim, not itemized, for part of alleged expenses in zoological department in 1860, amounting to $164.55, was not presented till

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[1] Winchell. Sparks from a Geologist's Hammer, p. 270. Compare Geological Report of 1861, especially pp. 165, 166.

April 17, 1861, after exhaustion of the appropriation for 1859–60, and was subsequently paid, without indorsement by the State geologist, by order of the board of State auditors.

THE GEOLOGICAL SURVEY FROM 1861 TO 1869.

The report of the work accomplished under the appropriation of 1859 was submitted to the legislature of 1861 and published by its authority, as already stated. That appropriation being exhausted, it remained with the legislature of 1861 to determine the question of the continuance of the survey. The country was in a state of extraordinary political excitement, and business was everywhere in a condition of partial paralysis. Nevertheless, the outgoing governor, Moses Wisner, recommended in his message the continuance and completion of the work. Through inadvertence, the State geologist neglected to furnish the incoming governor, Austin Blair, with any digest of his forthcoming reports or recommendations respecting the future disposition of the enterprise; nor did Governor Blair seek any information from the director. Accordingly he made no recommendation concerning it in his message. The legislature, however, determined to keep the survey alive and appropriated $2,000 for the year 1861 and $2,000 for 1862. They also discontinued expenditures for zoological work.

Unavoidably the State geologist was compelled to devote much time and attention to the legislature, to the general interests and reputation of the survey, and to the passage of his report through the press. The disturbance of the country grew more and more threatening after the adjournment of the legislature, and the auditor general, Emil Anneke, deemed it inexpedient to indorse the State geologist's draft for expenditures to be incurred on account of field work. Further exploration was therefore suspended. The State geologist, however, found abundant occupation in working up paleontological materials accumulated during the two preceding years, and he made several geological trips at private expense.

Financial statement for 1861.

Legislative appropriation	$2,000
Salary of State geologist	1,000
Unexpended	$1,000

An indebtedness of $51.87 was incurred to A. D. White for services to April 17, 1861, which was subsequently paid by order of the board of State auditors.

Subsequent to 1861 all State expenditures on account of the survey were discontinued by order of Gov. Austin Blair. The late State geologist, however, continued to serve the people of the State as before, and they seemed generally to regard him as still in the employ of the State. As the Civil War, which had broken out, was generally supposed destined to short duration, he exerted himself to preserve for the survey a quasi existence, believing the next legislature would be able to make fresh provision for its support. He therefore attended personally to a very large correspondence, and freely advised citizens, touching the numberless geological questions which they presented.

In July, 1862, he revisited the Saginaw Valley and made detailed investigations of the borings of numerous salt wells between Saginaw and Bay City. The result of this study was the conclusion that the shallower Bay City wells were supplied from the Parma sandstone, though the deeper ones, like those located farther up the river, were supplied from the Napoleon sandstone. This conclusion, together with the reasoning employed to reach it, was first announced in the Saginaw *Courier.* It followed that the coal measures in Michigan are a third and uppermost salt basin; and this led the way to the subsequent generalization that the basin-shaped conformation of the Michigan strata has caused all of them to retain a large portion of their original saline constituents.

Public interest in the discovery of petroleum was now rapidly rising, and the late State geologist made a professional and scientific study of all the oil regions east of the Mississippi River. Special studies were made of certain districts in Michigan, and his views were embodied in sundry reports and communications to newspapers and scientific journals. He recorded the opinion that the bituminous shales of Wayne, St. Clair, and Sanilac counties were of the same geological age as those within the limits of the oil region of Ontario. He taught that the oil-yielding Genesee shale underlaid some of those parts of Michigan, and the equivalent of the Marcellus shale was also present. But the conditions of oil accumulation and retention did not appear to be favorable. Still, he maintained that some possibility existed of such a rock condition somewhere in the region as would permit the accumulation of the oil and gas which he regarded as undergoing constant production, and some distinct evidence of which could be detected at the surface.

The subject of official resumption of the survey was canvassed among members of the legislature of 1863, and Professor Winchell, by invitation, delivered an address before the body in February; but apprehensions respecting the future of the country still restrained all expenditures not immediately essential. A special appropriation,[1] however, of $1,500 for 1863, and a like sum for 1864, was made to provide that a suitable person should visit the "salt localities" of the State and "make a special survey thereof," with direct reference to the feasibility of salt boring; also to "collect and arrange suitable specimens of the different strata obtained from salt borings, and the same to arrange in a suitable cabinet in some room of the capitol." No public report exists showing the expenditure of this appropriation; and hence the way in which the proposed work was expected to serve the interests of the State remains obscure.

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[1] Laws of Michigan, 1863, No. 212.

In 1865 Governor Crapo brought the subject of the survey formally before the legislature in his inaugural address. He said:

> A full and complete geological survey of the State has never yet been effected, and when it is remembered that for every dollar heretofore expended in this work we have received hundreds and even thousands in return, I submit to your judgment and discretion the propriety of making such appropriations for the speedy prosecution of the work to its final completion as its present condition and the importance of the subject demand. In my opinion the required outlay would be fully justified, even in times like these, in view of the value of information which would thus be acquired.

Professor Winchell, by invitation of the State Agricultural Society, delivered an address on The Soils and Subsoils of Michigan in Representatives Hall, January 19, 1865, in the presence of the legislature. A bill for the completion of the survey was introduced in the house January 23, 1865, by the committee on geological survey, to whom had been referred that part of the governor's message relating to the subject. Mr. J. Denison Lewis was chairman of the committee and embodied in the report accompanying the bill a communication from Professor Winchell in response to inquiries from the committee, in which were statements touching the condition of geological work in the State, and the desirability of its completion. This communication was ordered printed in the journal.[1] The bill, nevertheless, did not become a law.

In the autumn of 1865 Professor Winchell was invited by the citizens of the Grand Traverse region to make a special survey and report on the resources of the region. This work was accomplished, and the facts brought to light proved in many respects very extraordinary and surprising. It was found that the agricultural capabilities of the district in spite of the northern latitude equaled in most respects, and surpassed in others the central portions of Ohio. A study of meteorological records showed that the anomaly was due to an equable state of climate caused by the comparatively constant temperature of Lake Michigan, which had to be crossed by nearly all the cold winds of winter before reaching the State. These disclosures led to a very rapid development of settlement and improvement. The business of fruit raising, which had already gained some foothold in St. Joseph County, was at once extended northward to Grand Haven, Muskegon, Manistee, and Traverse City. The outcome has secured for Michigan a reputation for fruit production which is known throughout the country and extends even to the Old World.

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[1] House Journal, 1865, vol. 1, pp. 248–252.

THE GEOLOGICAL SURVEY IN 1869.

In his inaugural address to the legislature of 1869 Gov. Henry P. Baldwin took up the subject of the geological survey, and, after adverting to the efficiency of science in the development of public resources, recommended the adoption of a law reviving it. Petitions were received by the legislature from the Upper Peninsula, indorsed by leading citizens of Detroit, also from Grand Rapids, asking a liberal appropriation for completing the survey; and a bill appropriating $8,000 for such survey was introduced in the house by Mr. Yawkey. The petitions and the bill were referred to a joint committee, of which Lyman D. Norris was chairman of the senate committee, and John Q. McKernan chairman of the house committee. The joint committee canvassed the subject with much thoroughness and ability. Mr. Norris, especially, did the interests of the survey most important service. After a condensed historical summary of what had been done for the development of the resources of the territory embraced within the boundaries of the State, both while in a territorial condition, and when but just emerged from such condition, the committee recapitulated the results of the survey of 1859–1861 as follows:

> During the first year (they say) fully one-half of the appropriations was absorbed in zoological work. The geological results then are properly chargeable with only $4,000. The whole two years' work was, at the request of Governor Wisner, kept in the Lower Peninsula, principally because the means provided was not sufficient to inaugurate effective work in the upper. * * *
>
> The practical results of Doctor Houghton's survey are too far from our day to estimate, but those of Professor Winchell are nearer our time, and can be found, more or less, in the current and contemporary news of the day.
>
> A few of the results, addressed to those members of both houses who will hinge their vote upon the question "Will it pay?" your committee beg leave to refer to. Operations for coal in Hinsdale were arrested. The citizens of Grand Rapids were informed that if they would find brine they must go lower—to the Salina formation. The deepest and most productive salt basin was located beneath the Saginaw Valley [the committee here refer not to the "deepest" but to the middle one] and as the result of pure geologic induction, in remote portions of the State, before the first brine was seen; 850 feet was fixed as the depth at which good brine could be found [more accurately the bottom of the brine formation]—a prophecy verified almost to a foot by Doctor Lathrop in the Saginaw Valley. A complete table of geological forma-

tions of the Lower Peninsula and their equivalences with recognized groups in the States, was, for the first time, constructed. The existence of gypsum beneath a ridge of clay on the shore of Tawas Bay was insisted on, and the discovery of that deposit, the commercial value of which is now a matter of notoriety, was made under the direction of Professor Winchell. Projected borings for artesian water, searches for coal, gypsum, and petroleum have been favored or discouraged, and large outlays of money saved.

The existence of three salt basins was established, the upper of which supplies Bay City and vicinity (except the deep wells); the middle, the Saginaw; and the lower, the wells at St. Clair, Mount Clemens, and Port Austin. The wells at the three last-named places were undertaken under the advice of the State geologist purely upon geological calculations according to the methods of vigorous science. In the case of the St. Clair well the communications of the geologist with Colonel Whiting as to depth, supply, and strength of brine are instructive indications of the value of science in business enterprises.

The special survey and report upon the geology and climatology of the Grand Traverse region in 1866–67 has been the means (though wholly a private work) of turning the attention of the people to that country and has largely increased its population, particularly of those interested in fruit culture under the tempering influence of the waters of Lake Michigan.

More might be added, but this ought, in the opinion of your committee, to secure a liberal appropriation.

The bill introduced by the joint committee, after sundry amendments, was passed by both houses and approved by the governor, March 26, 1869 (see p. 204). It was entitled "A bill to provide for the further geological survey of the State." It enacted that "a board of geological survey" should be constituted by the governor, the superintendent of public instruction, and the president of the State board of education; and that "they shall control and supervise the continuance and completion of the geological survey of the State; that they shall appoint and commission a suitable person, possessed of the requisite knowledge of the science of geology, who shall be the director of the geological survey herein instituted." The board were to approve the appointment of assistants, to fix all salaries, to regulate all expenses, and to require such frequent reports as they might think useful.

The law required "a thorough geological and mineralogical survey of the State, embracing a determination of the succession, arrangement, thickness, and position of all strata and rocks; their mineral character and contents and their economical uses; an investigation and determination of the organic remains of the State; a general examination of the topography, hydrography, and physical geography of the State: an investigation of the soils and subsoils, and the determination of their character and agricultural adaptations; the investigation of all * * * productions of the geological world within the limits of the State capable of being converted to the uses of man."

Another section provided for the collection and exhibition of numerous sets of specimens. The sixth section required the preparation of a final report or "complete memoir under the direction of the board." Section 7 required that "one-half part of all appropriations made shall be expended in the Upper Peninsula." The appropriation made was $8,000 annually.

While the bill was pending the subject was brought up in the Board of Trade of Detroit, by whom, after a preamble reciting the benefits of geological surveys, a resolution was adopted earnestly recommending the passage of the bill.

Under the above law Alexander Winchell was, by Gov. H. P. Baldwin, commissioned as "director of the State geological survey" on April 24, 1869.

Widely diverse State interests seemed to necessitate three geographical divisions in the operations of the survey: 1, the Lower Peninsula; 2, the iron region; 3, the copper region. The chief mining industries were included in the Upper Peninsula, and the law had required one-half the appropriation to be expended there. The geological board decided that all expenditures for the general administration of the survey should be paid out of the half set apart for the Lower Peninsula. The work in the mining regions was supposed to be more difficult and expensive. Besides, the expenditures under the last survey had been confined to the Lower Peninsula—only, however, because the survey was terminated just at the time when the work had reached the northern part of the State.

Property holders in the iron and copper regions were equally anxious for the commencement of the survey, and there were indications that impatience would be the consequence of restricting the work for a season to either region alone. The board, therefore, decided at first that $2,000 should be spent in the copper region and $2,000 in the iron region. Under this arrangement the director proceeded to Lake Superior for the purpose of making himself acquainted by personal observation and intercourse "with the views, wants, and wishes of the people in that part of the State. I found the people of each of the metalliferous regions," he says in his report to the board dated December 20, 1869, "somewhat discontented at not receiving the entire appropriation assigned by the legislature to the Upper Peninsula."

It was also apparent that $2,000 a year was insufficient to maintain a system of field work or for entering upon any original investigations, either in the copper or the iron region. Much, however, could be done in the collection of data already on record in the offices of the mining companies and in the possession of private individuals. Much could be done in the discussion of such data, and the exhibition of the vast resources of the upper peninsula to the commercial and manufacturing world.

In accordance, therefore, with authority which I had received, I made a conditional agreement with Hon. John H. Forster, of Houghton, to conduct the investigation of the copper region in such manner as his experience might suggest as most conducive to the interests of the region, within the limits of expenditure fixed by the means at disposal. At my request he subsequently submitted a plan of operations.

* * * * * * *

In the iron region the director found equal regret at the necessity of accepting a moiety so small; but the people were in a cheerful mood, and much cordiality was manifested. The same considerations which had prompted to select a man from the copper region for the inauguration of the survey prompted now to select a man from the iron region for the work of the survey. With almost complete unanimity, Maj. T. B. Brooks was recommended for the position, and a contract was signed June 5, under which the work was to be performed, according to instructions by the director in consultation with Major Brooks and approved by him. The outline of detail in these instructions had been embraced in section 7 of the law, which was framed by Professor Winchell on request of the joint committee. They embraced not alone investigations of a strictly geological character, but also historical statements, statistics, and a full compilation of facts bearing on the finding, marketing, or reducing of the ores, including charcoal production, transportation facilities, and the like.

On reporting the results of the trip to the geological board they "modified their previous action," as the director's report states, "in such a way as to appropriate $4,000 to the iron region of the Upper Peninsula for 1869, and $4,000 to the copper region for 1870. This change rendered nugatory my arrangement with Mr. Forster; but by resolution, the board ratified my contract with Major Brooks, with the understanding that it was to be so modified that Major Brooks might prosecute his work as rapidly as convenience and economy might dictate—he to receive $4,000 in full for the completion of the work and the presentation of a report accompanied by maps, charts, and diagrams, according to instructions before referred to."

Major Brooks accepted the modification and devoted the season to a study of the Marquette district.

Unhappily, however, the representatives of the copper interest felt themselves greatly aggrieved, and they held the director of the survey responsible; but, for the present, their complaints were not loud.

In his report of progress for 1869, Major Brooks enumerated the following portions of work as accomplished:

1. A survey of the old and new Washington and Edwards mines, extending east and west nearly 2 miles and embracing about 400 acres. The proprietors aided to the extent of $200.

2. A survey of South Mountain in sections 4, 7, and 18, in T. 46, R. 29. Area, about 600 acres. Owners contributed $200. A complete section was obtained from the Laurentian granite on the northeast to the same rocks on the southwest. Two complete "magnetic sections" were also obtained.

3. A survey of the Lake Superior and Barnum mines. The owners provided for the topographical and working map.

4. The Cannon Iron Company's lot, sec. 28, T. 47, R. 30, was similarly surveyed. The company contributed $50. Area, 300 acres.

5. Iron Cascade property, 3,120 acres, in T. 47, R. 26 and 27, had been surveyed before the origination of the State survey.

6. Michigamme Lake and vicinity, including the Champion mine on the east and the Spur Mountain on the west. The survey was interrupted by close of season.

7. The Cleveland mine. This remained to be surveyed and mapped by the company's engineer during winter of 1869–70.

8. The New England and Parsons mine and the opening made in sec. 16, T. 47, R. 27, by the Lake Superior Iron Company were to be grouped in one map. This would receive the geology, which had been completely worked out.

9. The Foster and Tilden mines, surveyed by Major Brooks three years previously, required limited resurveys.

10. The Collins Iron Company's lot, SW. ¼, sec. 2, T. 47, R. 27, had been carefully examined geologically; but no topographical map was as yet available.

11. The old Michigan mine, sec. 18, T. 47, R. 28, was in precisely the same condition.

The above mines and properties were intended to be delineated each on a separate map, and the whole work was now something over half done. Major Brooks enumerated among those who had rendered efficient aid Edward Breitung, D. G. Johnson, E. R. Livermore, and A. W. Maitland.

> In organizing for work in the Lower Peninsula [says the director's report for 1869] I appointed as assistants, Profs. A. E. Dolbear and E. A. Strong. Professor Strong devoted only some portion of the summer months to his work. He made examinations and collected specimens in various parts of Kent and Ottawa Counties. He submitted a report accompanied by a map, diagrams, and a box of fossils. Professor Dolbear was to take charge of the field work in the northern part of the Lower Peninsula and contiguous shores of the Upper Peninsula. Prof. N. H. Winchell and Prof. E. Haanel were added as amateur assistants. With this party I proceeded to Traverse City on the 1st of July,

where we secured the principal articles of an outfit for field work. On our way there we had the opportunity to spend some time in Muskegon and Manistee and its vicinity. Having fully organized, we effected first, a very thorough investigation of Little Traverse Bay and its vicinity, collecting over a ton of specimens, which reached the headquarters of the survey in safety.

The hardships and perils of the work proving more serious than some of the party had anticipated, Professors Dolbear and Haanel withdrew and returned home. To meet the exigency thus enacted, I appointed Prof. N. H. Winchell to act as assistant during the remainder of the year.

Having refitted at Charlevoix and employed the requisite laborers, he proceeded under written instructions to make a geological and general survey of the shores of the inland waters accessible by the mouth of the Cheboygan River. This hydrographic system reaches within a quarter of a mile of the head of Little Traverse Bay.

While in the Grand Traverse Region I had made arrangements for an overland survey of the interior of some of the northern counties, which with some modifications, were put in execution on the 1st of September. Prof. N. H. Winchell and A. S. Wadsworth, having secured the requisite outfit, proceeded from Elk Rapids on foot, through the wilderness, to Otsego Lake, in Otsego County. This region embraces the headwaters of the Sable emptying into Lake Huron and of the Manistee emptying into Lake Michigan. On the headwaters of these streams they constructed a couple of canoes, in one of which Prof. N. H. Winchell, with an assistant, descended the Au Sable, while with the other Mr. Wadsworth, with his assistant, descended the Manistee. Each investigated the geology of the river bank and the contiguous country, and made note of all facts bearing upon the value of the region traversed, for lumber or cultivation, or for the purposes of a railroad thoroughfare.

Mr. N. H. Winchell having completed the survey of the Sable and some tributary streams, proceeded to Alpena and thence overland with his canoe, to Hubbard's Lake, whence he descended through Hubbard's River to Thunder Bay River. The latter river and its vicinity were also surveyed to the distance of some 20 miles from the mouth, and some extensive inland trips were performed. On the last of October the advent of snow and frost terminated field labors for the season.

Mr. Wadsworth having completed the survey of the Manistee, devoted the remainder of the season to the Little Manistee and Père Marquette Rivers. Returning to Traverse City, he drew up a map of the Grand Traverse region which exhibits in detail the distribution of the pine timber within the limits of the region, and submitted it in connection with his field notes.

In August I made an excursion with Mr. N. H. Winchell and Mr. M. W. Harrington to Widder and Bousanquet in Ontario, for the purpose of comparative observations on some remarkable outcrops of the Hamilton Group, and for collecting a store of fossils. In both respects the excursion was very successful.

I subsequently visited the islands on the western part of Lake Erie, where I was joined by J. S. Newberry, director of the geological survey of Ohio. The geology of these islands throws much light on that of southern Michigan; and this trip enabled me to add a new formation—the Lower Helderberg group—to the geology of the Lower Peninsula. I accompanied Doctor Newberry to Sandusky and Cleveland. At the latter place I had the opportunity of examining the collections of the Ohio survey—especially from the Waverly sandstone—which I am pleased to state, fully sustain positions which I have long held respecting

> the geology of the west, in opposition to the views of some high geological authorities.
>
> I have also embraced opportunities to extend my personal observations into Jackson, Eaton, Ingham, Shiawassee, Saginaw, Ottawa, Allegan, Lapeer, and Hillsdale Counties, in all of which I have aimed to supplement observations heretofore made by me, either in a public or private capacity. * * *

Opportunities for the collection of archaeological information were not neglected. Some mounds in Montcalm County were opened under the direction of J. B. Steere, and descriptions of the contents drawn up. Mr. Steere also supplied a collection of shells from Ionia County. Assistants Wadsworth and Winchell wrote for various newspapers popular accounts of the regions explored by them. Thus descriptions appeared of the Manistee River and Valley; one on the Père Marquette; one on the Sable; one on the Cheboygan region; and others on other portions of the State. Mr. B. F. Childs, of Houghton, was engaged to supply photographic views for the final report. Mr. J. H. Emerton had executed 289 drawings of organic remains. The director had carried forward and completed a paleontological investigation which had been several years in progress. For the purpose of securing unity and method in the prosecution of the various departments of the work, the director drew up and published a full plan of the operations of the survey.

Geological corps for 1869.—Alexander Winchell, director in charge of the general geology, the paleontology, and the physiography of the State; T. B. Brooks, assistant; Newton H. Winchell, assistant field explorer and laboratory adjunct. Mark W. Harrington, assistant laboratory adjunct and collaborator in phaenoganic botany, entomology, and ornithology. E. A. Strong, assistant field explorer and collaborator; A. S. Wadsworth, assistant field explorer. J. H. Emerton, draftsman. J. N. Armstrong, topographer and adjunct to Major Brooks; Oliver Newton, assistant to Major Brooks, surveyor; —— Heberlein, assistant to Major Brooks, topographer Lake Superior Mine. Collaborators: J. B. Steere, archaeology and conchology; W. J. Beal, cryptogamic botany; S. S. Garriques, salt statistics; C. B. Headley, statistics of lumber and fisheries, eastern slope; D. D. Hughes, ornithology; B. F. Childs, photography; William H. Brückner, chemist; J. G. Ramsdel, fruit statistics, northwestern slope.

Financial statement for 1869.

Appropriation for Upper Peninsula		$4,000.00
Total drawn to Dec. 20, 1869	$1,800.00	
Balance of appropriation	2,200.00	
		$4,000.00

Financial statement for 1869—Continued.

Appropriation for Lower Peninsula		$4,000.00
Salary of director, eight months, to Dec. 31	$1,000.00	
Salary of N. H. Winchell, six months, to Dec. 31	500.00	
Salary of M. W. Harrington, five and one-third months	222.22	
Salary of E. A. Strong	100.00	
Salary of A. S. Wadsworth, 62 days	243.00	
Salary of J. H. Emerton, two and two-third months, to Dec. 31	408.00	
Laborers	260.25	
Sundries to Dec. 20	775.00	
Permanent outlay (still on hand)	135.00	
Further expenses belonging to this year (approximately)	40.00	
Total approximate expenditures	$3,688.47	
Balance to next year (approximately)	311.53	
		$4,000.00

THE GEOLOGICAL SURVEY IN 1870.

On March 31, 1870, a meeting of the geological board was held in Detroit, at which the director explained his proposed plan of operations for the season. It consisted of the following features:

1. A survey of the Peninsula west of St. Mary River in the Upper Peninsula, by A. S. Wadsworth.

2. A survey of the coast of the Upper Peninsula from Point Seul Choix westward to Escanaba, by N. H. Winchell. A rendezvous to be made at Charlevoix about May 15.

3. Completion of the survey of the Thunder Bay region, by N. H. Winchell. Survey to begin September 1.

4. Collection of statistics of the fisheries, the forest and its products, from Cheboygan along the coast to St. Clair, by Charles B. Headley, at a cost of $125.

5. Collection of statistics of salt, with investigations and discussions, by S. S. Garrigues. Expense not to exceed $100.

6. Survey of Higgins and Houghton Lakes and the valley of the Muskegon River, by A. O. Currier. Expense not to exceed $150.

7. Collection of statistics of fruit production in Berrien, Van Buren, Allegan, Ottawa, Muskegon, Oceana, and Mason counties, by H. S. Clubb. Traveling expenses only to be paid. (A later agreement embraced the whole western shore of the State and involved an expenditure of $100.)

8. Collection of statistics of fruit in Manistee County, by Judge J. G. Ramsdell.

9. Collection of statistics of fruit, lumber, the forest, and fisheries from Manistee County to Duncan, by A. S. Wadsworth. Expense, $3 a day.

10. Completion of the survey of the Marquette iron region, by T. B. Brooks, under contract of 1869.

11. Survey of the developed portions of the copper region, by R. Pumpelly.

The foregoing plan, in all its features, was fully approved by vote of the geological board.

It had been the wish of the director to intrust the survey of the copper region to John H. Forster, a local geologist of good repute, with whom an agreement was reached in 1869, as already stated, before the board had determined to postpone the copper survey to 1870. But Governor Baldwin had promptly negatived his employment and expressed a wish that Professor Pumpelly be nominated. The director had already discovered indications of serious disaffection in the copper region, and felt that conciliation would be wise; but, acquiescing in the governor's judgment, he nominated Professor Pumpelly and the board made the appointment. Undoubtedly, the best interests of the survey would have been subserved by this selection if the offended temper of the copper region had not withheld cordial cooperation.

Before this hostility became fully known, however, a contract was signed with Professor Pumpelly. This was dated May 28, 1870, and $4,000 was the sum stipulated for compensation and expenses. It required, in addition to the specific work of geological investigation, that the report should treat of "all those matters which concern the well-being and prosperity of the copper regions as such." Professor Pumpelly left Ann Arbor for his field of work on the same date.

In the iron region the work of Major Brooks was continued at his private expense, since the whole appropriation available had been absorbed in 1869.

The work in the Lower Peninsula, and in some of the nonmetalliferous regions of the Upper Peninsula, was carried on in accordance with the plan already stated. Under this plan the entire expense of the general direction of the work, and of the general investigations in the climate, the physiography, and fruit, lumber, and farming statistics was developed on the moiety of the appropriation assigned to the Lower Peninsula.

THE GEOLOGICAL SURVEY IN 1871.

In his message presented to the legislature, January 4, 1871, Gov. H. P. Baldwin, referring to the geological survey, said:

> The director immediately (after his appointment) entered upon the discharge of his duties. Detailed plans for a systematic and most thorough exploration of the whole State were made, and two corps of assistants—one for each Peninsula—were organized.

> This important work has been carried forward as extensively and rapidly as the limited appropriation would allow. The results of the researches already made, and the work accomplished, will far more than repay the expenditures. * * * The value of these investigations and researches is of a permanent character, and not confined to any one section or interest of the State.
>
> The report of Professor Winchell will be laid before you and will be found full of interest. It also contains a carefully prepared estimate of the cost of properly completing this important work, undertaken by the State. I respectfully submit to your consideration whether it may not be advisable somewhat to increase the annual appropriation for this purpose, rather than prolong the survey for a series of years.
>
> No provision was made in the act of 1869 for printing or publishing the documents or reports which might be made from time to time. For information on this subject, I refer you to the report of the director. These reports, to be of service, should be published. I recommend that the State geological board be authorized to publish these reports when prepared by the director, and that proper appropriations be made therefor.

In pursuance of these recommendations the senate committee on geological survey, of which J. L. Morton was chairman, introduced, as early as January 16, bills making appropriations for publication and for the continuance of the work. These were accompanied by a highly appreciative and complimentary report, but far too rhetorical for usefulness. These bills passed through the committee of the whole, and were adopted January 19. The bill appropriating funds for publication received but one negative vote, and that for continuance of the survey but five negative votes. The house on January 17 appointed a committee to invite the director to deliver an evening address. On January 25 measures similar to those adopted by the senate were introduced in the house, accompanied by a highly appreciative report from the committee, of which Ira R. Grosvenor was chairman. These were referred to committee of the whole and placed on the general order.

In view of the favorable prospects, the director improved the opportunity offered by a trip to New York to institute some precise inquiries in reference to publication. On February 25 he entered into some definite but conditional negotiations with Julius Bien for printing and illustrations. The general form and style were to be those of the report of the fortieth parallel which was then in progress through Mr. Bien's establishment. Some of the maps to accompany the reports on the iron and copper regions were placed in Mr. Bien's hands.

Meanwhile, influences unfavorable to the continuance of the survey were at work, and learning that these were due to his attaching so much importance to the climatic elements of the State's natural resources, the director prepared hastily a pamphlet of eight pages, embracing two isothermal charts, for January and July, with a small amount of explanatory text. The charts were announced as illustrations of the paper on "Isothermals" appended to the "Report of Progress." This pamphlet brought to view as sharply as possible such facts as the following:

> Extreme cold at Milwaukee is 14° below extreme cold at Grand Haven. This difference is all that distinguishes between fruit-bearing region and one in which fruits fail. The growing season begins at Grand Haven 6 to 13 days earlier in the spring than it does at Milwaukee, and continues 5 to 8 days later in the autumn. The great climatic facts touched upon in this paper and more fully set forth in my Report of Progress possesses the utmost practical importance. * * * These facts are not known to the world. * * * The climate of our State is one of its greatest natural resources. To make this resource known to the world is an eminently practical work, etc.

A copy of the pamphlet was laid on the table of each member.

On March 14, on motion of Mr. Grosvenor, the house voted the use of the hall to the director for the purpose of an interview with the members, but without favorable result.

On March 16 there was introduced a report from which the following passages are extracted:

> It seems desirable that the act passed at the session in 1869 should be amended as provided by this bill; for the reason that an investigation is provided for in said act, in regard to a large number of subjects not belonging strictly to a geological survey, such as hydrography, climatology, meteorology, topography, magnetography, and physical geography of the State.
>
> There is also a provision in the act of 1869, above referred to, authorizing the "compiling and collecting of all useful knowledge" in relation to certain matters therein contained. This, in the minds of your committee, is a serious objection to the act. and an amendment is incorporated in the bill herewith reported, to obviate the same. A large amount of useful knowledge is contained in books heretofore published by various authors, and not only in a convenient form, but the books are easily to be obtained by the people who desire the information. * * *
>
> From the best information that your committee has been able to obtain in relation to the matter intended for publication, now in the hands of the geological board, they are of the opinion that the great bulk of the same is objectionable, for the reasons above stated; that it will be necessary to rearrange and condense it before the same is fit for publication; that, in fact, there is now nothing in readiness to be incorporated in the final report of the geological survey.
>
> Your committee would, therefore, report said joint resolution back to the House without amendment, and recommend that it do not pass.
>
> Your committee would also report said bill back to the House without amendment, and recommend that it do pass. * * *

The joint resolution, which provided for publication, was laid on the table; and the bill for continuing the survey was ordered printed, referred to committee of the whole and placed on the general order.

On March 18, on motion of Mr. Grosvenor, the joint resolution was taken from the table and referred to the committee on education,

Carl Ludwig Rominger, 1870-83

Thomas Benton Brooks 1869-73

Charles E. Wright, 1884-88

STATE GEOLOGISTS OF MICHIGAN.

of which C. B. Grant was chairman. Mr. Grant reported April 12 with an amendment. The latter was concurred in, and, after a further amendment, the resolution was lost by a vote of 34 to 46.

The house having by formal vote on March 18 refused to provide for the publication of the results of the survey, the director, on March 21, filed his resignation with the board, and on April 20 turned over, at a meeting in Detroit, all property of the survey remaining in his hands, and made a final settlement.[1]

It may be added that the house bill amending the law of 1869, introduced after various references and amendments, was passed April 11, concurred in by the senate April 12, and approved by the governor April 17. The effect of the changes introduced was to lodge the entire directorship in the hands of the geological board; to eliminate all investigations in paleontology, topography, physical geography, and climate; and it provided that the final report should not exceed three octavo volumes, and that they "shall not contain, in any considerable extent, compilations and extracts of or from books heretofore published."[2] The appropriation of $8,000 annually was continued and made payable until the completion of said survey.[3]

THIRD SURVEY UNDER BOARD OF DIRECTORS, 1871-1900.

Organization.—Under the board of directors authorized by the law of 1869, Dr. Carl Rominger, of Ann Arbor, was appointed director of the survey in 1871 and served until 1885. During the first year of his incumbency Major Brooks and Professor Pumpelly were continuing their researches in the western part of the Upper Peninsula, and for a time he was assisted by "several young men of the university who were recommended, * * * but none of them stayed with me over two or three weeks before they left, finding the occupation not so pleasant to them as they expected; and for my part, seeing not much benefit from their help in consideration of the considerable increase of the expenses, I concluded to go on with the work alone, simply assisted by ordinary laborers as packers, boatmen, and cooks."

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[1] This resignation, as the writer [Doctor Winchell] views the history of the time in the perspective of 16 years, appears to have been ill advised. The director, sure that he was right, and about to suffer wrong at the hands of others, should have held his post; and the geological board, under whose sanction every step had been taken, and who were ultimately responsible for everything, should not have accepted the resignation, but should have stood in a manly way to the defence of the director and the plan of the survey. The house might not, perhaps, have been induced to take different action, though that is by no means probable; but in the conflict, some discussion would have ensued, and some facts cunningly hidden would have been brought to light. Personal injustice would have thus been averted or duly exposed, and the true interests of the State would not probably have been compromised as they were. The resignation was prompted by disgust at the tricks of demagoguery, and a desire to avoid the distractions of a conflict. The act involved the practical loss of the results of several years labor, and left a moral impression which time was not destined to efface.

[2] It is not entirely clear what features in the proposed plan this prohibition was aimed at. The clause quoted in the report would make it appear that the requirement to compile and tabulate all information useful to the iron and copper industries was the offensive provision; but the discussion led to the belief that it aimed also at compilations of meterological and topographical data.

[3] The director's estimate of $61,300 for the completion of the field work was thought an astounding extravagance; nevertheless, the State in 16 years has already expended $128,000 besides appropriations for publications.

The following summary of the methods pursued and results obtained is taken from Doctor Rominger's manuscript notes:

As a continuation of the survey in the Lower Peninsula did not, under the then existing circumstances, seem to promise very important additional results, active operations were discontinued in the area, and his efforts confined chiefly to examining the azoic areas of the Upper Peninsula, a work which had been left incomplete by Brooks and Pumpelly. He here soon became convinced that this greatly disturbed and complicated complex of rocks could not be satisfactorily studied without first making a detailed study of a small area which should serve as a type and guide for subsequent work in the larger ones. He therefore selected an area near Marquette, where nearly all the members of the azoic series were displayed for the detailed study. As no good topographic map of the region existed he undertook to construct one for himself, using the Government Land Office maps as a base. In determining the position of hills, watercourses, and the larger rock exposures, he measured the distances by pacing, and the directions by the ordinary hand compass, taking section corners and quarter posts as initial points for the measurements, and at the same time making his geological obervations. In this way he surveyed over 200 square miles from the shores of Marquette westward. Commenting on this work later, Rominger remarked:

> I candidly confess that had I to do this over again I would no more attempt perform all the work myself, but would employ someone else to do the counting of steps and observing the compass while I was engaged with the examination of the geological features. Both occupations combined are too severe a strain on body and mind. On the other hand, I am satisfied that this *modus operandi* brought many things under my observation which otherwise would have escaped it.

The map prepared in this way, it should be stated, is the one issued in connection with the fourth volume (1880) of the survey reports.

During the seasons of 1880–1882 Rominger continued his examination of the azoic rocks near Lake Gogebic in the western part of the State, though a portion of the time was spent in a reexamination of the Fetch Mountain, Menominee, and Marquette districts. During the summers of 1883 and 1884 he devoted himself exclusively to the examination of the copper-bearing rocks on Keweenaw Point and in the Ontonagon and Porcupine Mountain districts. Rominger's final report, comprising the result of his last four years of work, was transmitted to the board of directors early in February, 1885. In April following he was superseded as State geologist by Mr. Charles E. Wright, of Marquette.

Salary and expenses.—The salary of the State geologist throughout Rominger's incumbency was $2,000 a year. The sum of $8,000 for each year of the survey was appropriated with the expectation that special appropriations would be made to pay the cost of publication. The two volumes published in 1873, at an expense of some $20,000, were thus paid for, but the volume of fossil corals, costing some $17,000, was paid for out of the unexpended balance of the appropriations, the expenses of the survey during 1874, 1875, and 1876 being not over $3,000 a year. The report issued in 1880 at a cost of upwards $4,000, was likewise paid for out of the survey appropriations. The total expenses of this survey are given on p. 238.

Distribution of publications.—According to the law every school and scientific institution in the State which was already in possession of a library of 1,000 volumes should receive the reports free of charge. Scientific men and institutions outside of the State were likewise favored at the discretion of the board. The remainder of the edition was to be sold at cost price. The edition of the report of 1873 (two volumes) was 2,000 as was also that of 1876 and 1880.[1]

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[1] It would appear from the following that these seemingly generous intentions were not carried out:

DRESDEN, SAXONY, *July 2, 1875.*

Hon. JNO. J. BAGLEY, *Governor.*

DEAR SIR: Yours of 10th inst. regarding distribution of the geological reports relating to the Upper Peninsula, is at hand, and I am delighted to learn that you have not entirely abandoned the idea of sending some of them abroad. The work was placed in your hands for distribution a year ago, and yet, judging by the letters enclosed, not one has yet been received on this side, Michigan enjoying the unenviable position of being the only civilized State in the world which has neglected to send her reports to the great libraries of Europe.

The Missouri and Ohio reports which appeared, the one nearly simultaneous with ours and the other some time after, have not only been sent to the libraries, but to the periodicals and were reviewed in England and on the Continent months ago; the attention of the people of Europe being thus called in the most effective manner possible to the resources of those States, and the advantages they offer for settlement and investment.

Geological boards outside of Michigan do not seem to regard their reports as intended exclusively for "home consumption." This policy seems to be in especially bad taste in Michigan, where a very large part of the brains, muscle, and money expended in the development of her resources came from outside the State.

Another use to which I believe a few copies of all geological reports heretofore published in the world, except those of Michigan, have been put, is in

Museum.—The law provided for the collection of geological and mineralogical specimens to be deposited in the museums of the State university, the agricultural college, and the normal school.

Under Professor Wright's administration field work during the season of 1885 "was confined chiefly to the north of township 48, and

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paying those debts of honor and courtesy which every survey has, in the nature of things, to contract in procuring needful information of various parties possessing it, but which can not be paid for in money. This was especially the case in the Marquette iron region, where there is no public record of mining and prospecting operations, no former surveys of which much use could be made, and where the small sum available for the work made it impossible for the survey to do all that was required. The result was, I was obliged to draw on the people and corporations interested and possessing the knowledge for a large part of my material. One furnished analyses, another private maps, others specimens, another history and statistics, others had special surveys made at my instigation, and gave the entire results to the State work. The result was the accumulation of 20 times more material (much of it yet unpublished) than all that had been accumulated before on the subjects embraced within the scope of the survey. There was manifestly but one way to repay these parties: First, to give them full credit for the assistance in the report, which I have endeavored to do in the introduction; second, to present them with a copy of the work which, as practically none were placed at my disposal, was the business of the board, and to facilitate the work I gave them a manuscript list of the parties named in the report, with their addresses (not the larger list prepared at the request of the board), and have since, both in letters and conversation, pointedly called their attention to the subject.

At the end of a year many of these parties have not received the report or any communication from the board on the subject, others have received the first volume and atlas, the second volume, which relates exclusively to the iron region, being withheld: others have only received the reports as the result of special effort on their part and mine to procure copies for them. Others, in answer to their communications, have been told they could have the work for $15, which they have bought. Others have had no notice whatever taken of their communications on the subject, being placed in this regard in the same category with the State geologists. I speak by the card on all these points. In short you seem to have paid no attention whatever to the obligations of the State to these parties. I trust she does not mean to repudiate any part of this debt. For the time being I am placed in a very awkward position toward these people, having acted as agent in securing the loans.

Those parties who have received the reports have not done so in virtue of having been mentioned by me, but because they accidentally came within the scope of your plan of distribution—whatever that may be.

I know that immediately on its publication complete copies were sent to every newspaper in Michigan. With but half a dozen exceptions, those papers are not read by people who have the slightest interest in the mines of the Upper Peninsula, while the newspapers and periodicals, east and west, which are read by those who own and administer the mines, and consume the ore, have never seen or heard of the work. One of these editors sold his copy to a Michigan furnace superintendent, who could not get one for $5. Another prominent Lake Superior mining man was presented with a copy by a "crossroad" politician, or from ranges 25 to 33, inclusive; that is, to the country to the north of the M. H. & O. Railway to the lake between Marquette and L'Anse, covering over 700 square miles of unexplored land." Unfortunately Wright died of pneumonia in March, 1888. According to Professor Wadsworth, who succeeded him, while he had planned and laid out the work on a broad scale, he had delayed putting his

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whom it had been thrust, who had not taken interest enough in the work to open the package in which it came.

Men who have tens of thousands invested in Michigan mines, and who have devoted their lives to their development, thereby bringing the State to the front rank in its mineral productions, must buy the report, or procure it at a late date by political influences or special effort; while petty editors and officeholders and political wirepullers, who can control a few votes, have it thrust on them at the earlist possible moment. Some copies of a State publication must, I suppose, be wasted on such people, but I believe they should be served after, and certainly not to the exclusion of people who really want to know something of the mineral wealth of Michigan and how to develop it; and also after those libraries and periodicals, whose business it is to teach the world scientific truth.

If you wish to know why I take the liberty of criticising you severely in this matter I will tell you: To say nothing of the personal slight—I can't look on it as less—of being entirely ignored in this matter of the distribution of my report by one who came into the administration of the survey when it was nearly completed, I ask your attention to the fact that I have nearly $3,000 in money, in addition to services which would have commanded $10,000 in the open market, invested in this work, besides to a great extent my reputation, which money can not measure. I have tried very hard to do my whole duty in this business and have spared neither my time, money, or personal sacrifice. You can therefore judge of my feelings when some of the most estimable men I know in and out of Michigan write me that my work has been used as a "campaign document."

I am tired of writing letters explaining that you are a very busy man and that if they will wait patiently justice will in the end be done.

Unless you furnish me something else to say, and that promptly, I shall in future answer these people with a copy of this letter, which meantime I send to Mr. Baxter, who may be as much to blame as you, for aught I know.

Very truly, yours,

(Signed) T. B. B.

P. S.—To answer your question—I can add nothing to what I said last summer. The Smithsonian Institution, Washington, D. C., is the usual channel through which such documents are distributed to foreign societies and libraries. I bought a copy and sent it to Sweden.

I do not believe my friend, Sir W. Williams, who is already interested in Lake Superior, and is very desirous of knowing more of it, will feel complimented by having a copy sent him on which he will have to pay not less than, say, $10 expenses. He will soon be able to buy the books in London, secondhand, cheaper.

I will undertake to distribute any copies sent me, provided I have full authority to draw on you for the actual cost, which I conceive would be small on a number of copies which could be sent as common freight through Baldwin Bros., 72 Broadway, New York. This is a central point for the whole of Europe.

results in writing except in a very minor degree. Being by nature cautious, he had endeavored to look over every part of the field before committing himself. After he had grasped the work in all its details, it was usual for him to put it into manuscript form with great rapidity, but in this instance "he gave himself no rest, but worked on and on until his vital force was exhausted, when he was taken away almost as suddenly as though struck down on the field of battle." As a result all his maps, field notes, specimens, and sections, indeed practically all the work accomplished except that of organization, were almost valueless.

With the death of Wright, as already intimated, Dr. M. E. Wadsworth, president of the School of Mines, at Houghton, became State geologist. Work was resumed during the season of 1888 in T. 43 N., R. 35 W., this point being selected on account of the field work having in large measure been completed westerly from Marquette to a line drawn from Iron River village northwardly to the south end of Keweenaw Bay, near L'Anse. During this season he covered the ground lying between Iron River and Lake Gogebic on the west and from the State boundary to township 46 on the north. Considerable attention was devoted to settling problems in connection with Mr. Wright's work. In his annual report for this year (1888–89) Doctor Wadsworth writes that thus far some 70 townships have been explored and their geology mapped with sufficient accuracy so that preliminary maps might be published such as would serve as great aid to the explorers. During the season of 1889–90 the work of mapping the area west of Gogebic Lake and south of the copper-bearing rocks and sandstones was completed, and township No. 45 surveyed. The published boundary of the copper-bearing rocks with the eastern sandstone, between Bete Gris Bay and southwesterly to Gogebic Lake, was also rectified, and careful excavations and surveys undertaken to ascertain the exact relations of the two formations. In 1890 the gold district was studied and special work was done in the Marquette iron region. In 1891 and 1892 field work began at Champion and the adjacent district and extended south of Clarksburg to Palmer and the vicinity of Negaunee. Later it was extended into the Huron Mountain district and into the limestone region in the vicinity of L'Anse, and the South Trap Range from Silver Mountain through to Lake Gogebic. Parties were also engaged in the Crystal Falls, Iron Mountain, Quinnesec, Norway, and Felch Mountain areas. In 1892 the work on the gas and salt wells begun under Wright's administration was continued.

Personnel.—Doctor Wadsworth's term of service as State geologist came to an end in 1893. Up to 1888 no geological assistant had been employed. In that year A. E. Seaman, who had previously served as topographer and woodsman, became assistant geologist, and in 1888 A. C. Lane was added to the force as petrographer. In 1890 the force was further increased by the addition of H. B. Patton, and in 1891 by L. L. Hubbard, all of the last three being petrographers with European training.

The expenses under Wadsworth's administration are given with others on page 238.

Doctor Wadsworth was succeeded in the office of State geologist by Lucius L. Hubbard, who held the position until 1899, when he resigned, to be succeeded in his turn by A. C. Lane. Both of the last named, it will be noted, had served as petrographers and assistant geologists under Doctor Wadsworth.

Salaries and expenses.—The salaries of the State geologist and others of the survey were by law left discretionary with the board of directors, the State geologist himself, up to 1885, receiving $2,000 a year, the annual appropriation being $8,000 a year, with the expectation that the expense of publication would be provided for by special appropriation. As has been noted, this was not, however, in all cases called for. The following table[1] shows the total appropriations and expenditures up to November, 1892.

Geological survey in account with the State of Michigan, 1837–1845.

DR.

Years.	For what drawn.	Amount.	Amount.
1837 1838	General purposes of survey		$16,026.00
1839	General purposes of survey		8,329.95
1840	General purposes of survey		7,161.37
1841	General purposes of survey		6,219.55
1842	General purposes of survey		1,263.13
1842	Salary of State geologist	$782.87	
1842	Salary of State topographer	624.53	
1842	Incidental expenses	1,032.82	
			2,440.22
1843	Salary of State geologist	1,000.00	
1843	Salary of State topographer	800.00	
1843	Incidental expenses	220.47	
			[2] 2,020.47
1844	Salary of State geologist	1,000.00	
1844	Salary of State topographer	800.00	
1844	Engraving expenses	338.16	
1844	Incidental expenses	397.30	
			2,535.46
1845	Salary of State geologist (to July)	500.00	
1845	Salary of State photographer	639.42	
1845	Engravings	658.92	
1845	Incidental	34.54	
			1,832.88
	Total		[2] $47,829.03
	Returned to State		[2] 4,170.97
	Total		[2] $52,000.00

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[1] From Report State Board of Geological Survey for the years 1891 and 1892.

[2] Figures have been corrected, as totals in the statement from which this was taken show palpable errors in addition.

Geological survey in account with the State of Michigan—Continued.

Cr.

Years.	Appropriation.	Amount.
1837	General purposes	$3,000.00
1838	General purposes	12,000.00
1839	General purposes	12,000.00
1840	General purposes	12,000.00
1841	General purposes	[1] 12,000.00
1842	No appropriation, there being balance to credit survey	
1843	No appropriation, there being balance to credit survey	
1844	For engravings	500.00
1845	For engravings	500.00
	Total	$52,000.00

Geological survey in account with the State of Michigan, 1859–1892.[2]

Year.	Amount drawn.	Amount charged out.	Amount appropriated.	Act.
1859	$ 2,000.00		(3)	206, 1859
1860	3,000.00		(3)	206, 1859
1861	750.00			64, 1861
1862	250.00			
1870	80.91			
1873	1,000.00			179, 1871
1874	5,000.00		$ 8,000.00	179, 1871
1875	2,000.00		8,000.00	179, 1871
1875	6,573.00			179, 1871
1876	5,000.00		8,000.00	179, 1871
1877	5,000.00	$2,919.09 7,927.00	8,000.00	179, 1871
1878	1,300.00	5,500.00	8,000 00	179, 1871
1879	1,500.00	6,388.33	8,000.00	179, 1871
1880	4,000.00	4,895.75	8,000.00	179, 1871
1881	2,453.76 6,000.00	5,462.16	8,000.00	179, 1871
1882	2,100.00	1,064.03	8,000.00	179, 1871
1883	4,000 00	5,900.00	8,000.00	179, 1871
1884	2,000.00	4,000.00	8,000.00	179, 1871
1885	4,000.00	6,000.00	8,000.00	179, 1871
1886	4,000.00	2,000.00	8,00.000	179, 1871
1886	2,000.00			
1887	2,000.00	4,000.00	8,000.00	179, 1871
July, 1887	2,000.00			
To July, 1888	6,665.44	1,344.56	8,000.00	179, 1871
July, 1888				179, 1871
To July, 1889	8,000.00		8,000.00	179, 1871
July, 1890	8,397.36	1,602.64	8,000.00	179, 1871
To July, 1891	5,738.93	1,604.29	8,000.00	179, 1871
July, 1891	7,950.44	49.56	8,000.00	179, 1871
July, 1892				
To Nov. 22, 1892	4,849.49	3,150.51	8,000.00	179, 1871
Total	[4] $109,609.33	[4] $63,807.92	$160,000.00	

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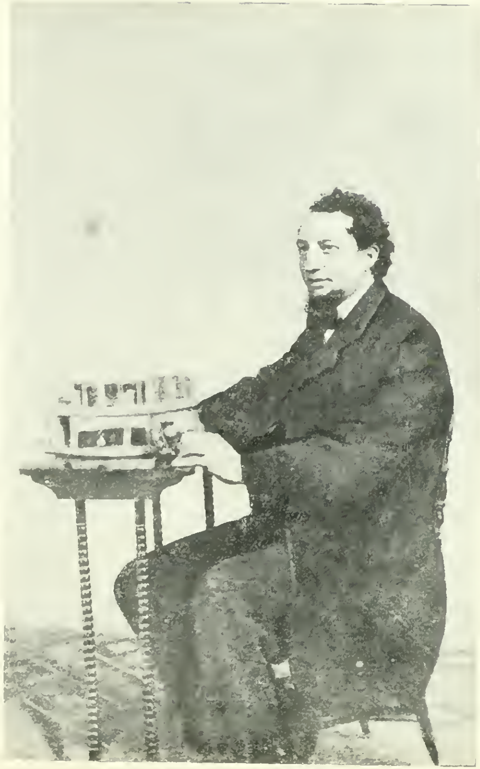
[1] According to statement compiled from books of the auditor general (see page 198) there was an appropriation of $12,000 for the year 1841.

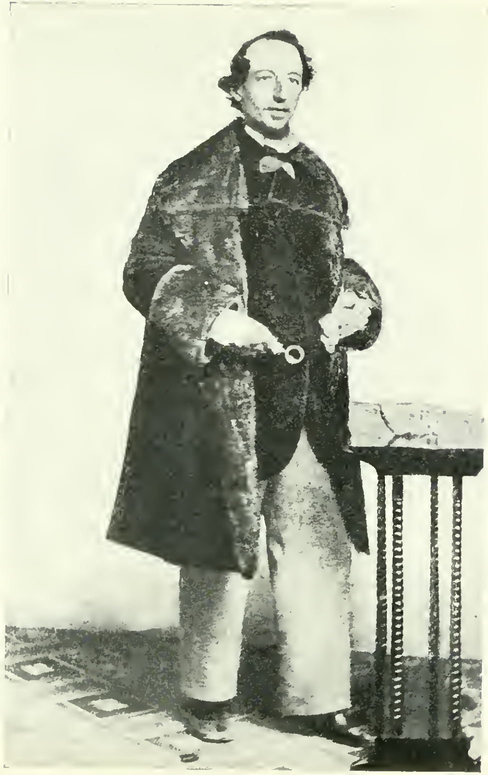
[2] It has been found impossible to make these figures agree with those in Professor Winchell's manuscript as quoted in the earlier pages. It has been considered best, however, to quote the figures published in the Report of the State Board of Geological Survey for 1891 and 1892 both here and in the final summing up on page 538, where, in addition to the totals here given, the appropiation of $8,000 a year for eight years has been added as the estimated expenses from 1892 to 1900.

[3] General fund.

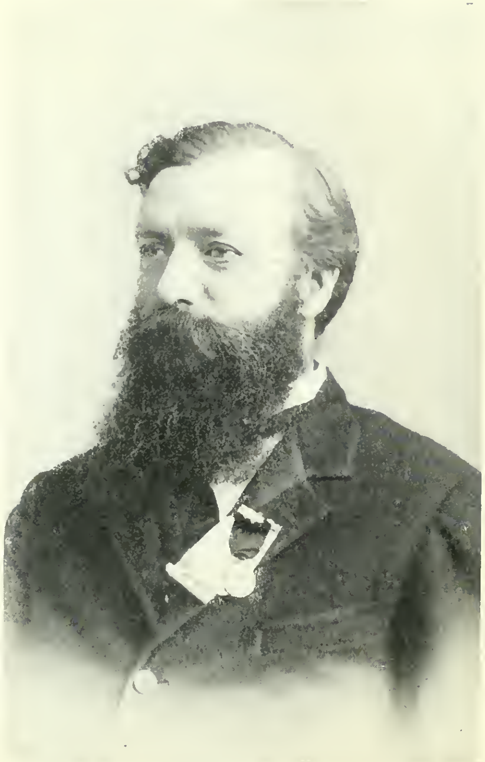
[4] Figures have been corrected, as totals in the statement from which this was taken show palpable errors in addition.



HENRY H. EAMES, 1865-66



R. E. EAMES, ASSISTANT GEOLOGIST, 1865-66



NEWTON HORACE WINCHELL, 1872-1900

STATE GEOLOGISTS OF MINNESOTA.

Connection with other institutions.—The survey as organized had no official connection with other institutions, although Doctor Wadsworth, during the period of his incumbency, was president of the mining school at Houghton, and cases for collections, heat and light, use of libraries, etc., were provided, rent free, on condition that certain assistance be rendered in the school by the employees of the survey when needed, and when it did not interfere with their professional duties on the survey. Cooperation was also arranged for between the State and the United States survey.

Museum.—Prior to Doctor Wadsworth's administration the survey had no permanent headquarters, and collections, if made, were soon scattered. Of the collections made prior to Professor Wright's appointment none are stated to have been handed down to him. Under his administration and that of Doctor Wadsworth, who succeeded him, upwards of 7,000 selected specimens were brought together and several thousand thin sections were prepared. These it is to be inferred were kept in the survey rooms at the mining school. The board of directors in their report for 1891–92 recommended that there be set aside for the survey a room in the capitol.

The above recommendation was evidently not adopted, since Hubbard in his report for 1894 (dated November) speaks of the survey now having a building of its own.

MINNESOTA.[1]

The first effort of the State of Minnesota to institute a survey of her domain was made in 1858 in the first legislature that met after the admission of the State into the Union. No general law was passed, but a reprint was ordered of a portion of former reports by Prof. Edward Daniels on the geological survey of Wisconsin, in which State Minnesota had then latterly been embraced.

The commissioner of statistics, Joseph A. Wheelock, also included in his official reports for the years 1859–60 general summaries of the physical features and agricultural capabilities of the State, which went far toward recommending the State to eastern immigrants. The facts, however, were derived not so much from original observation as from newspaper articles, reviews, and correspondence. These reports were widely distributed and introduced the State in its diversified natural resources favorably to the rest of the Union, which, undoubtedly, was the prime object of their author.

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[1] See History of Geological Surveys in Minnesota. Bull. Geol. and Nat. Hist. Survey, No. 1, 1889, by N. H. Winchell.

FIRST GEOLOGICAL SURVEY UNDER A. H. HANCHETT AND H. H. EAMES, 1864–1866.

An attempt to establish a regular geological survey was made by the second State legislature, which adopted a "concurrent resolution" ordering the appointment of commissioners to report on the geology of the State, and on a plan for a geological survey. These commissioners made separate reports, setting forth the utility of such a survey, but owing to the financial burdens which the young State had to bear, incident to the inauguration of the various public institutions, and the opposition of Governor Ramsey, the legislature did not take any further action on the subject.

The legislature of 1864, however, by joint resolution, authorized the governor to appoint and direct a State geologist. The following is the text of the law:

An act to provide for a geological survey of the north shore of Lake Superior within the limits of the State, and other mineral and coal districts, and to appropriate money therefor.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. That there be, and is hereby, appropriated, out of any moneys in the treasury not otherwise appropriated, the sum of $2,000, to be expended, or so much thereof as may be necessary, under the direction of the governor, in causing to be made a geological survey of the mineral lands on the north shore of Lake Superior, within the limits of this State, and also of other mineral or coal districts of the State, and the governor is hereby authorized to appoint a suitable person or persons to make such survey, whose report of the same shall be made to the governor, and by him transmitted to the legislature.[1]

Approved, March 4, 1864.

Administration.—Under this law Dr. Aug. H. Hanchett was appointed State geologist. With him was associated Mr. Thomas Clark, who had been one of the "commissioners" of the resolution of 1860. These gentlemen made each one report for 1864, that of Mr. Clark containing some valuable information concerning the physical features of the northern part of the State, but adding little or nothing to the actual geology. For a report of progress on the first year's work, limited in time and means, the pamphlet containing these two papers may be considered a creditable production, and had the survey been continued as planned by Mr. Clark, it might have become useful and successful. But it became apparent that Doctor Hanchett was not intelligently and wholly devoted to the work, and on the passage of a more general act by the legislature of 1865 the governor conferred the position of State geologist upon Mr. Henry H. Eames. The following is the text of the new law:

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[1] This same year the following memorial was submitted to Congress, though evidently without effect:

Memorial of the legislature of Minnesota praying Congress to make an appropriation for a geological survey of the mineral lands on the north shore of Lake Superior within the limits of the State of Minnesota.

Mar. 10, 1864. Referred to the Committee on Public Lands and ordered to be printed.

To the Congress of the United States of America:

Your memorialists, the Legislature of the State of Minnesota, respectfully request that your honorable body will appropriate money and make provision for a geological survey of the mineral lands on the north shore of Lake Superior within the limits of this State, believing that thereby the interests of the General Government and of this State would alike be greatly promoted.

An act to continue the geological survey of the mineral lands of the north shore of Lake Superior and other mineral districts within the limits of this State, and to appropriate money therefor.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. That the governor be, and he is hereby, authorized and empowered to appoint some suitable person to continue the geological survey of the mineral lands of the north shore of Lake Superior, lying in the State of Minnesota, and also other mineral-bearing districts within the limits of this State.

SEC. 2. Such person so appointed shall, before entering upon his duties under the provisions of this act, take and subscribe an oath to diligently and faithfully discharge such duties to the best of his ability. And he shall proceed at as early a day as practicable to continue such survey under the direction of the governor. He shall make analyses of metal-bearing rocks that may be obtained during such survey, to the end that the commercial value thereof may be ascertained; and he shall report the same to the governor on or before the first day of January, A. D. 1866. He shall also make and report sectional maps showing the location of minerals examined and analyzed, and as far as in his power report upon the extent of the coal fields on the waters of the Big Cottonwood River, and the extent of such other mineral deposits as he may find, and such report shall be transmitted by the governor to the legislature of the State.

SEC. 3. The governor shall have power to draw from the State treasury, out of any moneys not otherwise appropriated, a sufficient amount to pay the actual expenses incurred by such person so appointed under the provisions of this act not to exceed the sum of $1,000.

This act shall take effect and be in force from and after its passage.

Approved, March 2, 1865.

Under the same date there was also passed:

An act to enable N. C. D. Taylor to continue the geological exploration of the country in the valley of the St. Croix within this State.

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. That the sum of $1,000 be, and the same is hereby, appropriated and ordered to be paid, N. C. D. Taylor, out of any moneys in the treasury not otherwise appropriated, to enable him to continue the geological exploration of the country in the valley of the St. Croix within this State, and that he report to the next legislature the result of his labors.

SEC. 2. This act shall take effect and be in force from and after its passage.

Approved, March 2, 1865.

Mr. Eames made two brief annual reports of progress, one for 1865 and one for 1866. The former is devoted to an account of a bordering on Lake Superior, and the latter to observations on the "prospecting" tour made by him through the metalliferous region geology of some of the north-central counties of the State. It was owing to the discoveries of Mr. Eames that the gold fever centering on Vermilion Lake rose in speculative mining circles. This prevailed for about two years and subsided after the legislature refused further appropriations for the geological survey. Mr. Eames was assisted by his brother, R. E. Eames.

The notes and observations of Col. Charles Whittlesey made in Minnesota at various times, sometimes for parties at private expense and sometimes for the United States Government, were printed at the cost of the State of Minnesota and issued at Cleveland, Ohio, as a "report of explorations in the mineral regions of Minnesota during the years 1848, 1859, and 1864," dated 1866. As a geological report this unpretentious brochure is, according to Professor Winchell, of more value than all the previous reports issued under the auspices of the State combined.

Mr. N. C. D. Taylor, who was authorized by act (see p. 241) of the legislature to make surveys for copper in the valley of the St. Croix and the Kettle rivers, made a brief report occupying about one octavo page, which was printed in the executive documents (for 1866?), giving an account of his operations and quoting the verbal opinion of Prof. James Hall.

In 1870 Prof. A. Winchell was appointed by the governor to examine and report on the reputed salt springs at Belle Plaine with a view to ascertaining the propriety of appropriating money to aid in the development of the same by the State legislature. The published report is an octavo pamphlet of 16 pages and was the last work of the kind done through the instrumentality of the State before the beginning of the survey of 1872–1888.

SECOND GEOLOGICAL AND NATURAL HISTORY SURVEY UNDER N. H. WINCHELL, 1872–1888.

The law which organized this survey was drawn up by President William W. Folwell, of the University of Minnesota. This, before it was offered in the State legislature, was shown to some geologists and educators who might have opinions or advice to offer as to its provisions. There is no question but one of the prime motives was to introduce another auxiliary force into the State university, by making it the center whence should radiate information concerning the natural features of the State, and toward which should gravitate all collections of natural history that should otherwise be brought to light. It would furnish information, perhaps to the body of students through its officers, to the State at large, and to the country through its reports, and in its museum would be seen the outward proofs of the resources of the State and the means of illustrating the natural sciences as they should be taught in the university. The actual and minute study of the natural history of the State was, perhaps, a secondary motive, although this is specifically required by the terms of the law. It is a comprehensive law, and was introduced into the State senate by Regent J. S. Pillsbury. Having passed both houses, it was approved by Gov. Horace Austin, March 1, 1872. It reads as follows:

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. It shall be the duty of the board of regents of the University of Minnesota to cause to be begun as soon as may be practicable and to carry on a thorough geological and natural history survey of the State.

SEC. 2. The geological survey shall be carried on with a view to a complete account of the mineral kingdom, as represented in the State, including the number, order, dip, and magnitude of the several geological strata, their richness in ores, coals, clays, peats, salines, and mineral waters, marls, cements, building stones, and other useful materials, the value of said substances for economical purposes and their accessibility; also an accurate chemical analysis of the various rocks, soils, ores, clays, peats, marls, and other mineral substances, of which complete and exact record shall be made.

SEC. 3. The natural history survey shall include, first, an examination of the vegetable productions of the State, embracing all trees, shrubs, herbs, and grasses, native or naturalized in the State; second, a complete and scientific account of the animal kingdom, as properly represented in the State, including all mammalia, fishes, reptiles, birds, and insects.

SEC. 4. The said surveys and examinations shall be made in the manner and order following: First, the geological survey proper, together with the necessary and implied mineralogical investigations; all of which shall be undertaken as soon as may be practicable, and be carried forward with such expedition as may be consistent with economy and thoroughness; second, the botanical examinations; third, the zoological investigations: *Provided, however*, That whenever the said board of regents may find it most economical to prosecute different portions of the surveys in conjunction, or that the public interest demands it, they may, in their discretion, depart from the above-prescribed order. And in the employment of assistants in the said surveys, the board of regents shall at all times give the preference to the students and graduates of the University of Minnesota, provided the same be well qualified for the duties.

SEC. 5. The said board of regents shall also cause to be collected and tabulated such meteorological statistics as may be needed to account for the varieties of climate in the various parts of the State; also to be caused to be ascertained [by] barometrical observations or other appropriate means, the relative elevations and depressions of the different parts of the State; and also, on or before the completion of the said surveys, to cause to be compiled from such actual surveys and measurements as may be necessary, an accurate map of the State; which map, when approved by the governor, shall be the official map of the State.

SEC. 6. It shall be the duty of said board of regents to cause proper specimens, skillfully prepared, secured, and labeled, of all rocks, soils, ores, coals, fossils, cements, building stones, plants, woods, skins and skeletons of animals, birds, insects, and fishes, and other mineral, vegetable, and animal substances and organisms discovered or examined in the course of the said surveys, to be preserved for public inspection, free of cost, in the University of Minnesota, in rooms convenient of access and properly warmed, lighted, ventilated, and furnished, and in charge of a proper scientific curator; and they shall also, whenever the same may be practicable, cause duplicates in reasonable numbers and quantities of the above-named specimens to be collected and preserved for the purposes of exchanges with other State universities and scientific institutions, of which latter the Smithsonian Institution at Washington shall have the preference.

SEC. 7. The said board of regents shall cause a geological map of the State to be made as soon as may be practicable, upon which, by colors and other appropriate means and devices, the various geological formations shall be represented.

SEC. 8. It shall be the duty of the said board of regents through their president, to make, on or before the second Tuesday in December of each and every year, a report showing the progress of the said surveys, accompanied by such maps, drawings, and specifications as may be necessary and proper to exemplify the same to the governor, who shall lay the same before the legislature; and the said board of regents, upon the completion of any separate portion of the said surveys, shall cause to be prepared a memoir or final report, which shall embody in a convenient manner all useful and important information accumulated in the course of the investigation of the particular department or portion; which report or memoir shall likewise be communicated through the governor to the legislature.

SEC. 9. To carry out the provisions of this act the sum of $1,000 per annum is hereby appropriated, to be drawn and expended by the (said) board of regents of the University of Minnesota.

SEC. 10. This act shall take effect and be in force from and after its approval.
Approved March 1, 1872.

This is the organic law which remained in force in all its provisions throughout the life of the survey. The legislature in some of its subsequent sessions, however, passed laws to facilitate the execution of this, or amplifying some of its provisions, but in no respect was a single clause of the law abrogated or modified.

Although the law of 1872 was approved on the 1st day of March, the regents took no action looking to its execution till the July following, when Prof. N. H. Winchell was summoned to St. Paul from active field work in the State of Ohio to meet the board of regents there in session and to assume the position of State geologist under this law. Engagements in Ohio, however, would not permit the beginning of the season's work till September.

A moment's examination of the law was sufficient to convince Professor Winchell that the sum of money appropriated for the work was wholly inadequate for the purposes which the law contemplated, and it was evident that the legislature did not so much expect the law would effect a complete survey of the State as that it would pay for the services of an officer at the university who should be made useful in any way the regents should find it convenient to have him work, giving particular attention to the natural sciences. The survey in this respect was not in an encouraging position, and the appointment at its head implied that the man who accepted it would either fail ignominiously or must find some way to increase the means that were vital to its continuance and its success. It was in view of this that the first annual report closed with the following recommendation:

> In connection with the subject of increasing the means provided for the geological survey, it is suggested that the State lands known as Salt lands may be so sold or appropriated, under the management of the board of regents of the university, as to be available for that purpose. It would be in perfect consonance with the original design in the reservation of these lands from sale, if they were placed in the custody of the board of regents, conditioned in their use on the prosecution of the geological and natural history survey of the State, with a view to the early and economical development of the brines of the State.
>
> * * * * * * *
>
> The question of the existence of brine in the State of Minnesota is one of the most important, in an economical sense, that can be presented for the investigation of the survey. It should not be hastily answered. Too much is involved to be rested on the result of a guess. Too much also is involved to be prejudiced by the failure of unguided expenditures. The tests that may be made ought to be made in the fullest light of all the facts that science with its generalizations can throw upon them. It comes within the scope of geological investigation, and ought not to be hazarded in the hands of empirical novices.
>
> The salt springs said to occur in this State may have either of two origins: They may be the results of overflow of extensive salt basins embraced in the rocky structure of the State, or they may be the result of superficial accumulations similar to the other saline and alkaline deposits that are scattered largely over the western plains. It is not intended now to give this question the discussion its importance demands at the hands of the survey. No investigation of the phenomena of the regions where these springs exist has been made. It is only intended to suggest the importance of correct scientific processes in the future efforts for their development.

It was fortunate for the survey that at this juncture the public became convinced pretty generally that the legislative aid sought by the Belle Plaine Salt Company, which had been granted by the donation of some of the salt spring lands of the State, even contrary to the recommendation of the geologist, was a scheme to make inroads on the salt spring lands more than for an exploration in good faith of the brine springs that were said to exist at Belle Plaine. It was evident that unless some other use were made of this United States land grant to the State, other enterprising communities or mining companies would discover salt water and would demand more of these lands to aid in the development of the same. Indeed, Professor Winchell was hardly known to have been appointed State geologist before he was requested to accompany the officers of the Belle Plaine Salt Company to some other part of the State in order to designate where the next deep well should be sunk for finding brine at the expense of the salt spring lands. Several far-seeing public officers, it seems, about the same time suggested that these lands be saved for some better purpose. Among those who had thus conferred and had concluded that these lands might be appropriated to the maintenance of the geological and natural history survey of the State, should be mentioned A. J. Edgerton, then State railroad commissioner: H. B. Wilson, superintendent of public instruction: O. P. Whitcomb, State auditor: and J. S. Pillsbury, one of the regents of the university.

The suggestion first came to Professor Winchell from Mr. W. D. Hurlbut, of Rochester, and it was almost solely through his representatives that the following rough draft of a law was prepared by the State geologist and forwarded to J. S. Pillsbury, with a request that he would remodel it according to his judgment and offer it in the State senate of the following winter. Mr. Pillsbury, however, turned it over to Senator Edmund Rice, of St. Paul, who introduced it exactly as drafted, and so it passed both houses and was approved by the governor. The following is the text of the law:

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. The State lands known as State salt lands, donated by the General Government to aid in the development of the brines in the State of Minnesota, shall be transferred to the custody and control of the board of regents of the University of Minnesota. By said board of regents these lands may be sold in such manner, or in such amounts, consistent with the laws of the State of Minnesota, as they may see fit, the proceeds thereof being held in trust by them, and only disbursed in accordance with the law ordering a geological and natural history survey of the State.

SEC. 2. It shall be the duty of the said board of regents, as soon as practicable, to cause a full and scientific investigation and report on the salt springs of the State, with a view to the early development of such brine deposits as may exist within the State.

SEC. 3. The board of regents of the university shall cause the immediate survey and investigation of the peat deposits of the State of Minnesota, accompanied by such tests and chemical examinations as may be necessary to show their economical value, and their usefulness for the purpose of common fuel; a full report thereon to be presented to the legislature as soon as practicable.

SEC. 4. The sum of $2,000 is hereby appropriated annually (in lieu of $1,000) for the purpose of the geological and natural history survey until such time as the proceeds of the sales of the salt lands shall equal that amount, when such annual appropriation shall cease.

SEC. 5. The sum of $500 is hereby appropriated for the purchase of apparatus and chemicals for the use of the geological and natural history survey, the same to be expended by the order of the board of regents of the University of Minnesota.

SEC. 6. It shall be the duty of the board of regents of the University of Minnesota to cause duplicate geological specimens to be collected, and to furnish to each of the three normal schools suites of such specimens after the university collection has become complete.

SEC. 7. When the geological and natural history survey of the State shall have been completed, the final report on the same by the said board of regents shall give a full statement of the sales of the salt lands hereby given into the custody and control of the board of regents of the University of Minnesota, together with the amount of money received therefrom, and of the balance, if any, left in the hands of said board of regents.

SEC. 8. This act shall take effect and be in force from and after its passage.

Approved, March 10, 1873.

It is reasonable to suppose that after the passage of this law all private schemes for the development of fictitious salt springs and the reduction of the fund by doubtful attempts at exploration would cease, but such was not the case. A bill was introduced in the house of representatives at the next session of the legislature to grant the Belle Plaine Salt Company more land in aid of their enterprise, requiring the board of regents to give up to that company a certain amount of the salt spring lands for every 100 feet deeper that company should sink their well at Belle Plaine, aggregating six sections of land in all. It was duly referred to the proper committee, but was never reported for consideration by the house.

The salt spring lands originally granted the State aggregated 46,080 acres. By various inroads and conflicts with other grants, the selections made by the State not having been duly certified and reserved from the available public domain, the amount that was found capable of being used for the survey was only 18,771 acres. The officers of the United States Government were responsible for this deficit, as Governor Silby, the first governor of the State, had complied with the law and all the terms of the grant in having them selected. When this fact was represented to the State legislature, a memorial was passed, addressed to Congress, asking the privilege of making reselections of land in the State of Minnesota sufficient to make the deficit good to the State. Such permission was granted and 24 sections were added to the available land grant of the geological survey. These, however, were not turned over to the regents for this purpose till the winter of 1885, when the legislature passed the following:

An act to transfer to the custody and control of the board of regents of the University of Minnesota the lands granted by Congress to the State by an act entitled "An act granting lands to the State of Minnesota in lieu of certain lands heretofore granted to said State," approved March 3, 1879, to authorize the said board to sell such lands and dispose of the proceeds of such sales.

Whereas the State lands known as State salt lands were by an act approved March 10, 1873, chapter 133, general laws of 1873 transferred to the custody and control of the board of regents of the University of Minnesota, to be by said regents sold, and the proceeds thereto held in trust by them, and disbursed in accordance with the law ordering a geological and natural history survey of the State; and

Whereas it was found that certain parcels of such State lands had been otherwise disposed of by the United States to actual settlers upon such lands, for which indemnity lands have since been granted to the State by an act of Congress approved March 3, 1879: Therefore

Be it enacted by the legislature of the State of Minnesota:

SECTION 1. That the lands granted by Congress to this State by an act entitled "An act granting lands to the State of Minnesota in lieu of certain lands heretofore granted to said State," approved March 3, 1879, be, and the same are hereby, transferred to the custody of the board of regents of the University of Minnesota, which lands the said board may sell in such amounts as they may deem most expedient and beneficial, the proceeds thereof being held in trust by them, and only disbursed in accordance with the law ordering a geological and natural history survey of the State, and the said board shall make report of their doings in the premises, as provided by law.

SEC. 2. This act shall take effect and be in force from and after its passage.

Approved February 24, 1885.

Administration.—The administration of the survey was almost wholly in the hands of the State geologist. He was left to lay such plans as he chose, governed by his own apprehension of the financial, economic, scientific, and educational circumstances that might be influenced by them. These were submitted to the regents or to their executive committee prior to their execution for their formal approval. In some instances certain public or widespread want for information, expressed in correspondence or in the public press, such as the demand for information concerning the grasshopper plague and the ways and means of alleviating the evil, the call for peat fuel on the woodless prairies, the ravages of insects injurious to horticulture, the general belief in the existence of coal in the State or of mineral wealth in the northern part of the State, the demand for authoritative statements founded on scientific data touching the nature and extent of the forests, or the quality of the soil, or the water used for domestic purposes, or the probability of brine for the manufacture of salt, or the quality of native building stones. While answering these purposes as nearly as possible the survey was rendered useful to numerous individuals by private correspondence, saving the useless expense of ill-guided exploration in many instances, and directly influential in promoting economic industry by advising expenditures where a reasonable expectation existed of remunerative results.

This economic side of the survey was kept in mind constantly, though not made conspicuous. The annual reports embodied common, patent facts, and descriptions, cast in a semiscientific mold. They were addressed primarily to a home constituency in order to show them the utility of the work of the survey. It is highly probable that if such a moderate course had not been pursued the legislature, instead of always manifesting good will and determination to have the work well sustained, would have refused the financial aid that was asked of it, and the work might have had the short-lived existence that has been the fate of so many other State surveys.

Personnel.—N. H. Winchell, State geologist, 1872–1888; Warren Upham, assistant geologist, 1879–1885; C. W. Hall, assistant geologist, 1878–1880; C. M. Terry, laboratory assistant, 1879–1881; O. E. Garrison, occasional field assistant; P. L. Hatch, ornithologist, 1876; C. L. Herrick, zoological collector and laboratory assistant, later in charge of mammalia, 1876–1885; L. B. Sperry, geological assistant, 1877; P. B. Rose, chemist, 1873; S. F. Peckham, chemist, 1873–1880; James A. Dodge, chemist, 1881; M. W. Harrington, assistant geologist, 1875; Allen Whitman, entomologist, 1876–1878; Benj. Juni, botanical and field assistant, 1878; P. P. Furber, field assistant, 1873; C. E. Chatfield, field assistant, 1873; W. E. Leonard, botanical and field assistant, 1875; H. V. Winchell, field and laboratory assistant, 1881, 1885; Albert H. Chester, report on the iron region, 1882; Leo Lesquereux, paleobotanist, 1883, 1886; O. W. Oestlund, entomologist, 1885; U. S. Grant, conchology, 1885; J. C. Arthur, botanist, 1885; E. O. Ulrich, paleontologist (bryozoans), 1885; F. L. Washburn, assistant in ornithology, 1885; A. Woodward and B. W. Thomas, foraminifera of the Cretaceous, 1886; Frank N. Stacy, field assistant, 1886; A. W. Jones, field assistant, 1886; A. Winchell, assistant geologist, 1886; M. E. Wadsworth, assistant geologist, 1886.

The selection of these men was made by the State geologist, but their appointment was always passed on by the regents or by their executive committee. The only guide in making the selections, aside from availability and fitness for the work, was the clause in the general law requiring the employment of students and graduates of the University of Minnesota, when such could be found qualified for the work, and a general enactment of the regents to the effect that the professor of chemistry at the university should, by virtue of his position, be the chemist of the survey.

These men were not continuously employed, even for the time expressed above, except in the case of the State geologist, Warren Upham, C. M. Terry, and O. W. Oestlund, but were engaged during the season of field work, or to perform some specific work for which they had such compensation as the services demanded.

The salary of the State geologist was $2,400; salary of Warren Upham was $1,200; C. M. Terry, $1,200; O. W. Oestlund, $900; C. L. Herrick, from $600 to $1,200.

The chemist was paid a percentage of schedule prices for work done for the survey. Dr. P. L. Hatch, the ornithologist, worked for the survey from pure love of birds and asked only the payment of his field and traveling expenses. Other employees were paid by the month from $50 to $100, or by the job.

Museum and library.—The general museum of the university is the outgrowth of the survey, and during the existence of the survey it was sustained by the survey fund. The report of 1889 gave the entries in the geological and mineralogical department 6,190, and in the zoological 1,633, embracing several times as many specimens. In archeology the entries numbered 198. Besides these, several valuable collections were deposited by their owners for exhibition and safekeeping.

The library of the survey contained, as reported in 1889, perhaps 225 books and pamphlets, obtained by exchange and by purchase, and was stored in the office of the State geologist at the university, where it was available only to the officers of the survey or to students specially interested.

Expenses.—The annual cost of the survey was between $3,000 and $4,000, the aggregate from 1872 to August 1, 1884, being $39,267.10. These figures do not include printing and publication. The annual reports were printed as State documents at the expense of the general printing fund, under the direction of the commissioners of public printing. They were transmitted as a part of the reports of the regents of the university. The final report was published by the commission specially appointed for that purpose, according to the general law already given, and the cost met from time to time by special appropriations by the legislature. The edition of the annual reports was 2,400 copies and of the final report 5,000 copies. The former were distributed gratuitously and the latter sold at $3.50 and $5 a copy, according to the style of paper and binding, though of the latter also a generous free distribution was made to libraries and scientists in this and foreign countries, according to the foregoing law.

The sums received for the support of the survey by the university treasurer during the various years were as follows:

1872, cash from State treasurer	$1,000.00
1873, cash from State treasurer	2,500.00
1874, cash from State treasurer	2,000.00
1875, cash from State treasurer	2,000.00
1876, cash from State treasurer	2,000.00
1877, cash from State treasurer	2,000.00
1878, cash from State treasurer	2,000.00
1878, cash sale of salt spring land (balance)	2,893.64
1879, cash from State treasurer	2,000.00
1880, cash sales of salt spring land	6,822.89
1881, cash sales of salt spring land	2,158.80
1882, cash sales of salt spring land	6,539.43
1883, cash sales of salt spring land	8,451.17
1884, cash sales of salt spring land	4,539.72
1885, cash sales of salt spring land	4,423.95
1886, cash sales of salt spring land	5,349.05
1887, cash sales of salt spring land	2,971.01
1888, cash sales of salt spring land	1,955.31
	$61,604.97

Of this sum, as will be noted, $15,500 was received from the State treasurer as the proceeds of the laws of 1872–73 making direct appropriations for its support, and $46,104.97 was derived from the sale of salt spring lands.

Publications.—The legislature of 1876 passed the following law relating to the printing of the annual reports of progress of the survey:

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. One thousand copies of that portion of the annual report of the board of regents of the University of Minnesota which embraces the report of the State geologist on the progress of geological and natural history survey of the State shall hereafter be paged and bound separately, and shall be subject to the disposition of the said board of regents.

SEC. 2. Whenever in the progress of said survey a full and final report shall be made on the geology of any of the counties of the State, 500 extra copies of each county report so made by the board of regents shall be printed for the use of the counties so reported on, said copies being subject to the order of the county commissioners of said county.

This act shall take effect and be in force from and after its passage.

Approved March 6, 1876.

The legislature of 1885 also made provision for the publication of the final report of the survey by the enactment of the following general law:

Be it enacted by the Legislature of the State of Minnesota:

SECTION 1. The governor, the secretary of state and the State geologist are hereby created a commission for the printing and publication of the reports of the regents of the university on the geological and natural history survey of the State.

SEC. 2. It shall be their duty to supervise the printing of the final reports of said survey and the engraving of the accompanying maps and illustrations, in such style and manner as they shall determine and judge best calculated to exhibit to the people of the State the natural resources of the State as required by the law creating the geological and natural history survey.

SEC. 3. They shall cause to be republished in the same manner the third, fourth, and fifth reports of progress of said survey at as early a date as practicable, in an edition of 2,000 copies.

SEC. 4. The volumes of the final report of said survey, as they may be prepared by the State geologist from time to time, shall be issued in an edition of 5,000 copies each, and shall be distributed, in the name of the board of regents of the university, under the direction of the State geologist, to scientific and educational institutions and to individuals as follows: To the library of each chartered college and scientific institution in Minnesota, three copies; to each normal school, three copies; to the libraries of the institute for the deaf and mute, the insane asylums, the State prison, and every public library in the State not otherwise designated, one copy each; to each of the offices in the capitol, one copy; to each member of the board of regents, three copies; to the library of the State university, 200 copies; to the historical society and to the Minnesota Academy of Sciences, 10 copies each; to each newspaper published in the State, one copy each; to each senator and representative of the present legislature, one copy each; to the governor and lieutenant governor, each one copy; to each assistant on the survey who has furnished manuscript and illustrations published in the report, three copies; to the general office of each railroad that has furnished aid to the survey, three copies; to the library of each high school, furnishing students fitted for the freshman class of the State University, one copy; to the State library of each State in the Union, one copy; to each State university and each college of agriculture and mechanic arts, one copy; to geologists and naturalists of Minnesota, 50 copies; to the geologists and naturalists of other States, 200 copies; to other colleges and scientific institutions in the United States, 100 copies; to foreign institutions and scientists, 100 copies; and to the State geologist, 25 copies. The remainder shall be deposited in the State University, and shall be sold at such prices as the board of regents may determine, and the proceeds of such sales shall be used by said regents for the purchase of apparatus and books for the survey, and, after its completion, for the departments of natural science at the State University.

Sec. 5. The expense of printing, engraving, binding, and distribution of said reports shall be paid out of any moneys not otherwise appropriated in the State treasury, on warrants of the State auditor, approved by the governor and secretary of state.

Sec. 6. The commissioner hereby appointed shall perform the duties herein designated without further compensation than the payment of the actual expenses incurred in the discharge thereof.

Sec. 7. This act shall take effect and be in force from and after its passage.

Approved March 7, 1885.

These comprise all the laws that have passed the legislature respecting the present survey. The fund on which the survey depends arises entirely from the sale of lands intrusted by the legislature to the board of regents. The regents manage the sales according to their judgment, limited only by the State law that requires no State land to be sold for less than $4 an acre. This minimum price would produce a fund which in the aggregate reached $136,524.

The geological and natural history survey is one of the important wards of the university, and is constantly demonstrating the wisdom of the law that made it one of its functions to conduct it. The mutual benefits that spring from this relationship need not be dwelt on here.

Benefits.—If no mention be made of the invisible benefits that result to the State, and particularly to the university, by the prosecution of this survey, it will perhaps be proper to enumerate some of the tangible beneficial results that have accrued to the people of the State directly through the agency of the survey:

1. Beginning with the inauguration of the survey, the first that should be mentioned is the fact that the professorship of geology and mineralogy, with the added work of instruction in botany and zoology, in the university, was maintained for six years solely at the expense of the survey fund. This also included much of the equip-

ment, cases, maps, and apparatus of that department. The same fund also placed several hundred dollars' worth of books in the general library of the university.

2. The salt spring lands of the State were saved from being gradually devoured by such enterprises as the Belle Plaine Salt Company, and were appropriated, through the direct interposition of the survey at a critical juncture, to the prosecution of this far-reaching public enterprise.

3. On the discovery after a laborious investigation of the official records of the fact that the State was still entitled to a large additional amount of land under the original grant, the initial efforts of the survey were successful in obtaining from the United States about 15,000 acres of indemnity lands, which have since been devoted by the legislature to the support of the survey.

4. The general museum of the university is one of the tangible beneficial results of the survey.

5. There was a widespread belief among the citizens of the southern part of the State, prevalent when the survey began, that workable coal of the age of that found in Iowa could be discovered by making the proper exploration, and individuals had incurred considerable expense on such efforts looking for it. One of the first efforts of the survey was to settle this question; and the published result of such investigation went far toward stopping further useless expenditure of money.

6. The agitation of this subject by unscrupulous prospectors and well drillers culminated in a proposed law, which was introduced in the legislature of 1877 (?) offering a reward of $20,000 for the discovery in the State of "coal" in workable quantities. This law was so drawn that it did not discriminate as to the age or the quality of the coal to be discovered; and anyone familiar with the Cretaceous lignites of the State could have made a legitimate demand for the reward within 60 days after the adjournment of the legislature. Through the agency and advice of the State geologist this law was adversely reported by the committee having it in charge. It is only on the principle that "a penny saved is 2 pence gained" that this can be claimed as one of the tangible effects of the survey.

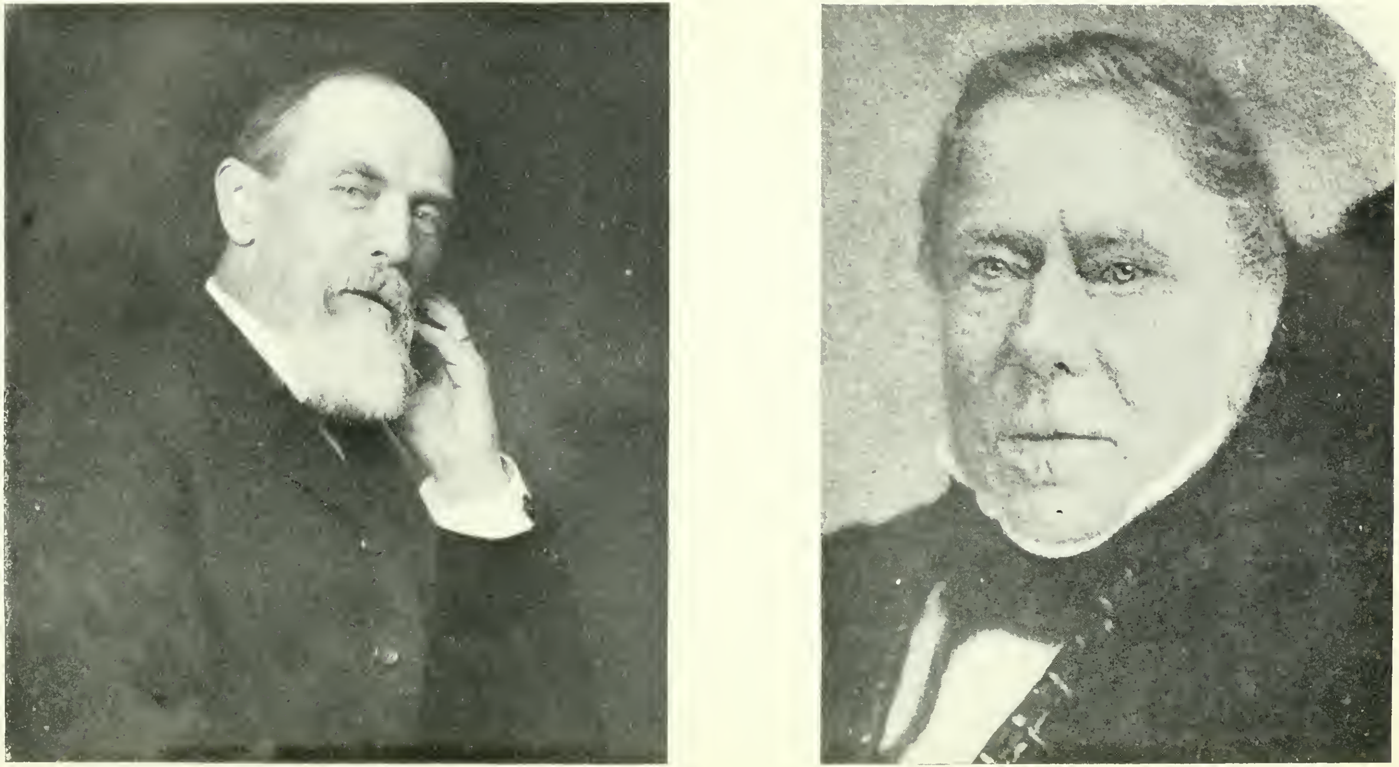
7. A similar law ordering the appointment of a "commissioner on peat," at a salary of $2,000 a year, was also defeated in the State legislature, largely through the influence of the survey, in 1874.

8. A law ordering the donation of further subsidy to the Belle Plaine Salt Company, and another for the investigation of the grasshopper plague, and another appointing a "State mineralogist," with special reference to supposed great wealth of the State in gold and silver, each looking to the unguided expenditure of the revenues of

the State, were severally proposed in the State legislature, and were either rejected or shown to be unnecessary by the existence and the agency of the survey.

9. In the prosecution of the regular work of the survey general attention has been called to the economic resources of the State. The survey has been directly instrumental, either in instigating in the first instance or by guiding by counsel when once begun, nearly all the industries of the State arising from the rocky substructure. This has been done officially and by private correspondence. The native building stones especially have been compared with those from other States and some of their excellencies have been brought out prominently, resulting in a great increase of the use of stone native to Minnesota.

10. In 1879 an examination was made of the water used for domestic purposes in the western part of the State. It had been discovered that very many of the common wells were foul, and that serious diseases that frequently terminated fatally were traceable to the use of the water in this condition. So general and widespread was this that serious alarm was felt by parties who were largely interested in the settlement and habitability of the prairies, particularly in the valley of the Red River of the North, lest the growing evil should render the country unfit for general agricultural occupancy. But the examination showed that the evil was due, not to any unwholesomeness inherent in the water, but to the general habit of using white pine for curbing for the wells. In the open air, water, which is naturally alkaline, confined in the impervious clay reservoirs, such as nearly every well was, will act rapidly on any organic matter that comes into contact with it. The pitch of the pine was thus converted into organic acids, giving off hydrogen disulphide. Infusorial organic germs took up their abode in the foul waters and the natural result of the use of such water inevitably followed. It was at once recommended that the use of wooden curbing be abandoned and that in its place some earthen stone, brick, or iron substance be substituted. This recommendation was widely published, both in Minnesota and the newspapers of Manitoba. The consequence was a rapid decline of the evil. Many wells which had been abandoned were recurbed with other materials. It was very soon known that pine curbing generated disease, and in a year or so nothing more, or very little, was heard further concerning the supposed foul waters of the western prairie portion of the State. The correction of this evil and the removal of the supposed alarm that was felt by some capitalists and by the health officers of the State may be considered one of the most important visible benefits that have resulted from the survey.



EUGENE WOLDEMAR HILGARD, 1858-60

JOHN MILLINGTON, 1850

STATE GEOLOGISTS OF MISSISSIPPI.

At the same time the survey called attention to the possibility of obtaining artesian water at a moderate depth in the drift deposits over a wide tract of country in the northwestern part of the State—a circumstance that has latterly been widely improved with the most satisfactory results.

While these material benefits can easily be enumerated, those that are invisible can not so readily be pointed out. Some good must result from a diffusion of knowledge concerning the physical features of the State, and from the publication of accurate statements concerning its natural undeveloped resources. There must be some benefit to the State in having its geology and natural history known. The scientific facts that are ascertained help to swell the data on which important conclusions are based, and to point out needed corrections in others that may have been published. The additions to science which have resulted from the survey can not here be enumerated. They are the common property of educators and scientists who may wish to use them, and, at the same time, some of them are still subject to further investigation, and hence can not be concisely described nor categorically stated.

MISSISSIPPI.[1]

Organization.—The geological and agricultural survey of the State of Mississippi had its origin in an act of the legislature entitled "An act to further endow the University of Mississippi," approved March 5, 1850, which took effect on the 1st of June following. This act is worded as follows:

> SECTION 1. *Be it enacted, etc.,* That the further sum of $3,000 be, and the same is hereby, semiannually appropriated, subject to the draft of the president of the board of trustees of the University of Mississippi, to be applied by them to the purchasing of books and apparatus, and the payment of the salaries of professors and assistant professors of agricultural and geological sciences in said university: *Provided,* That one half only of the amount of said appropriations shall be from the revenue in the treasury and the other half shall be made out of the sale of the lands belonging to the seminary fund, hereafter to be sold as provided by law.
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> SEC. 2. That the authority required by the State treasurer for the payment of the trustees shall be the warrant of the president of the board of trustees, drawn in favor of any person whatever.
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> SEC. 3. That at least one-half of the amount herein appropriated shall be expended in making a general geological and agricultural survey of the State, under the direction of the principal professor to be appointed under the first section of this act.
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> SEC. 4. That the survey herein provided for shall be accompanied with proper maps and diagrams, and furnish full and scientific descriptions of its rocks,

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[1] See Historical Outline of the Geological and Agricultural Survey of the State of Mississippi, by E. W. Hilgard. American Geologist, vol. 27, 1901, pp. 284-311.

soils, and geological productions, together with specimens of the same; which maps, diagrams, and specimens shall be deposited in the State library, and similar specimens shall be deposited in the State University and such other literary institutions in the State as the governor may direct: *Provided*, That the survey shall be made in every county in this State.

SEC. 5. That the trustees of the State University shall cause a report to be made annually to the governor, to be by him laid before each session of the legislature, setting forth, generally, the progress made in the survey hereby required.

SEC. 6. That this act take effect and be in force from and after the 1st day of June next.

In 1852 this law was amended as follows:

An Act to amend An act to further endow the University of Mississippi, approved March 5, 1850, the provisions of which are as follows:

SECTION 1. That the fourth section of the above-recited act be so amended as to read "zoological" instead of geological productions.

SEC. 2. That the room adjoining the State library, formerly occupied by the surveyor general, be appropriated and set apart for the deposit and safe-keeping of such specimens as may be collected during the progress of the geological survey provided for in the above-recited act, and that the sum of $200 be appropriated, out of any money in the State treasury not otherwise appropriated, to defray the expense of fitting up and preparing said room for the reception of said specimens.

SEC. 3. That the fitting up of said room shall be done under the direction of the governor, upon whose requisition the auditor shall issue his warrant for the sum herein appropriated, or so much of said sum as may be necessary.

SEC. 4. That the said room after being so fitted up shall be under the charge of the State geological society, who shall be authorized to employ the librarian as curator of the same.

SEC. 5. That the said room shall be open to the public during such hours as the State library is now required by law to keep open, and the librarian shall be allowed an additional compensation of $50 per annum for the services required by the fourth section of this act.

In 1854 further legislation relative to publication was enacted, as below:

An Act to authorize the printing of the first annual report of the agricultural and geological survey of the State.

SECTION 1. *Be it enacted by the Legislature of the State of Mississippi*, That 2,000 copies of the report of Prof. B. L. C. Wailes, State geologist, be printed under his supervision, in quarto form, and in such manner and with such illustrations and plates, as his excellency, the governor, shall deem appropriate and necessary for its illustration.

SEC. 2. *Be it further enacted*, That, when printed and bound, the said report be deposited in the office of the secretary of state, to be by him distributed as follows: Fifty copies to be deposited in the State library; 25 copies to be deposited in the State University; one copy to each State in the Union; one copy to be given to each incorporated college and academy in the State; one copy each to the governor, secretary of state, auditor of public accounts, State treasurer, adjutant general, the chancellor and vice chancellors, the judges of the high court of errors and appeals, the attorney general, the judge and district attorney of each district, each member of the present senate and house of representatives; and 100 copies to the said State geologist, to be by him exchanged for similar reports from other States, and to furnish to scientific societies and public libraries.

SEC. 3. *Be it further enacted*, That 1,000 copies of said report shall be deposited in the office of the secretary of state, to be sold by any agent or agents to be appointed by the governor, under such regulations and for such sum each as he may deem proper and advisable, for the purpose of reimbursing the State for publishing the same, and the balance to be distributed among the several counties of the State, in proportion to their representation in the legislature. to be furnished to the people thereof, in such manner as the boards of police of the several counties may direct.

SEC. 4. *Be it further enacted*, That, previous to the printing of said report, it shall be revised and completed by the said State geologist; and the portion of it which treats of zoology, as far as prepared, shall be omitted, and in lieu thereof a catalogue of the fauna of the State, as far as ascertained, shall be substituted.

SEC. 5. *And be it further enacted*, That, for the further and more efficient prosecution of the survey, analyses of the marls. soils, mineral waters, and the chief agricultural productions of the State shall be made at the University of Mississippi, as the trustees may designate; and the State geologist may, from time to time, furnish such soils, marls and waters as may be required for analysis, and shall receive in return from the chemist full and precise reports of all analyses which may be made; and specimens of soils and marls shall be preserved in convenient glass bottles in the State cabinet, and in the cabinet of the State University, properly labeled with the chemical character of the substance and the locality from which the same was obtained.

SEC. 6. *And be it further enacted*, That the said geologist shall make collections of specimens to illustrate the mineral character and paleontology of the State, in addition to the zoological productions which by law he is now required to collect, and to cause them to be suitably arranged and preserved in the State cabinet and in that of the university; and any duplicates that remain may be distributed by him among such of the incorporated colleges in the State as may apply for them.

SEC. 7. *And be it further enacted*, That a sum not to exceed $2,500 be appropriated out of any money in the treasury, to be drawn upon the requisition of the governor, for the purpose of carrying into effect the provisions of this act.

SEC. 8. *Be it enacted*, That this act shall be in force from and after its passage.

Approved March 1, 1854.

In 1857 a portion of the act of 1850 was repealed and certain other changes made, according to the following:

[Extract of act to provide for the printing of the Second Annual Report of the Agricultural and Geological Survey of the State, and for other purposes.]

SECTION 1. *Be it enacted by the Legislature of the State of Mississippi*, That so much of "An act to further endow the University of Mississippi," approved March 5, 1850, as appropriates out of the treasury $3,000 per annum to aid in making an agricultural and geological survey of the State, and also so much of said act as connects the said survey in any manner whatever with the university, be, and the same is hereby, repealed.

SEC. 2. *Be it further enacted*, That the agricultural and geological survey of the State shall be prosecuted to completion according to the provisions of the above-recited act, and of an act entitled "An act to authorize the printing of the First Annual Report of the Agricultural and Geological Survey of the State," approved March 1, 1854, by a State geologist, to be appointed by the governor.

SEC. 3. *Be it further enacted*, That the State geologist shall keep his office in the city of Jackson, etc.

SEC. 6. *Be it further enacted*, That 5,000 copies of Professor Harper's report be printed, under the direction of the governor, to be bound in boards, with such plates, charts, and woodcuts therein, as his excellency may deem appropriate and necessary for its illustration.

SEC. 7. *Be it further enacted*, That when said report shall be printed and bound, it shall be distributed according to the provisions of the last-recited act.

SEC. 10. *Be it further enacted*, That the State geologist to be appointed under the provisions of this act shall enter upon the discharge of the duties of his office on the first Monday in March, 1857, and this act shall go into effect from and after its passage.

Approved January 31, 1857.

Still again, in 1860, there was passed:

An act to prosecute the geological survey of the State of Mississippi, and for other purposes.

Be it enacted by the Legislature of the State of Mississippi:

SECTION 1. That the Governor of this State be and is hereby authorized to appoint an assistant State geologist, who shall act in subordination to and under the direction of the State geologist, at an annual salary of not more than $1,500.

SEC. 2. *Be it further enacted*, That the expenses of the State geologist and his assistant shall be paid by the State, an accurate account of the same being kept by said officers, and reported to the governor of the State, as now provided by law for the State geologist, provided the same shall not exceed the sum of $1,300.

SEC. 3. *Be it further enacted*, That the sum of $545 be, and the same is hereby, appropriated out of any moneys in the treasury not otherwise appropriated, to reimburse the State geologist for expenses necessarily incurred in fitting up a chemical laboratory for making analyses in the prosecution of said survey, to be drawn from the treasury, upon the requisition of the governor, and paid over to said State geologist.

SEC. 4. *Be it further enacted*, That 5,000 copies of Dr. E. W. Hilgard's report be printed under the direction of the governor, to be bound in board, with such diagrams and maps as he may deem necessary for its illustration; and it is hereby expressly enjoined upon his excellency, in the publication of said book, to have the same performed in the South, if the same can be done at a cost of 10 per cent upon the cost of its publication in the North, and that same when published shall be distributed as provided by law for the distribution of Professor Harper's report.

SEC. 5. *Be it further enacted*, That the sum of $3,500 be placed at the disposal of the governor, to be drawn from the treasury, upon his requisition, to carry into effect the provisions of the fourth section of this act.

SEC. 6. *Be it further enacted*, That the State geologist may, at his election, keep his office at or near the University of the State of Mississippi, and he is

> hereby authorized to make the necessary arrangements, if the same has not already been made, for suitable accommodations for his collections and laboratory in that place; and that all laws in conflict with the provisions of this act be, and the same are hereby, repealed.
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> Approved February 10, 1860.

Administration.—Under the somewhat loose provisions and phraseology of the act of 1850 Dr. John Millington, at the time professor of chemistry at the University of Mississippi, was in June of that year appointed to the position of State geologist and additional duties provided for by it. No assistant was obtained until July 15, 1851, when Oscar M. Lieber, of South Carolina, was appointed to the position. No record or report of Lieber's work was made. During a portion of his incumbency (presumably in the autumn of 1852) he made, on horseback, a reconnoissance of the Yazoo Bottom, but nothing beyond that fact appears from the letters written by him under the regulation defining his duties, which provides that:

> When not actually engaged in making explorations and surveys, he shall aid the principal professor of geology, agriculture, and chemistry, in the discharge of his duties; and while engaged in making such surveys, he shall make reports at least monthly to the principal professor; and the salary of said assistant professor shall be $1,000 per annum.

Lieber resigned on January 14, 1852.

In January, 1852, the position of geologist was accepted by Prof. B. L. C. Wailes, then of the faculty of Jefferson College, near Natchez. This gentleman had already made a collection of rocks and fossils of the southwestern part of the State and had an extended knowledge of the general features of that region.

It will be noted that, by the verbal correction made in the first section of the act of 1852, the survey was practically made a complete natural history survey, since the only branch not specifically provided for (botany) might be understood to be necessarily included in the provision for an agricultural survey. The State society mentioned had but a very ephemeral existence during the two succeeding years, namely, 1852 and 1853. Mr. Wailes traveled chiefly in the southern and eastern part of the State, with his own team and outfit, examining the territory of the Cretaceous in northeast Mississippi and the Tertiary and Quaternary areas in the southern part of the State.

Collections of Tertiary fossils, especially from the shell bed at Jackson, were sent by Wailes to Conrad, and mammalian and other bones from the loess to Leidy, for determination and description; and collections of these and other fossils as well as of rocks were by him deposited both at Oxford and at Jackson.

In January, 1854, Wailes presented to the board of trustees of the University of Mississippi the manuscript of his report on the work of the two preceding years, which was transmitted through the governor to the legislature, with the recommendation that it be printed. The legislative committee to whom it was referred reported back the act of March 1, 1854, already referred to, under which the survey was thereafter carried on for a number of years.

It will be noted, further, as stated by Professor Hilgard, that, although the act of 1854 designated Wailes as State geologist, it did not create that office, which still remained an appendage of the chair of geology in the University of Mississippi. It was expected that Wailes would be elected to that chair, which in the autumn of 1853 had been vacated by Doctor Millington. At an election held in June, 1854, however, the choice fell on Lewis Harper,[1] then a teacher of natural science at an academy near Greenville, Alabama. Wailes thereupon immediately resigned his position, which remained vacant until September, 1855. Up to the summer of 1855, Harper, bearing the titles of professor of geology and agriculture and State geologist, had not taken the field himself. He was now, by action of the board of trustees, relieved of a portion of his duties as instructor, and directed to take the field personally, for the purposes provided for in the act, while Dr. F. A. P. Barnard, then professor of physics at the university, was requested to secure a competent assistant geologist at a salary of $1,000 a year during a contemplated visit to the North. Dr. Barnard fulfilled his mission by tendering the appointment to Dr. E. W. Hilgard, then lately returned from Europe, who promptly accepted it.

Reaching Oxford about the middle of September, 1855, Hilgard found that Harper had then just returned from a rapid reconnoissance of the Cretaceous and Tertiary prairie regions in eastern Mississippi, and it was agreed that they should as soon as possible set out on a joint exploration over the same route, to be continued to the Gulf shore, thence across the southern counties of the State to the Mississippi River. The start was made early in October, the outfit consisting of an ambulance carrying a camping outfit, and a negro driver, who at the same time performed the office of cook. The Cretaceous prairie country on the Tombigbee River was reached near Okolona, whence the route lay through Aberdeen to Columbus; thence, leaving the Cretaceous territory, through Neshoba and Kemper counties to Enterprise on the Chickasawhay River, and along that stream, crossing all the marine Tertiary stages, as far south as Leaksville, Green County, whence, owing to the lateness of the season, they were obliged to return to Oxford by way of Fort Adams, Mississippi, and Memphis, Tennessee.

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[1] Properly, Ludwig Hafner, of Hamburg, Germany, a law student, who, for political reasons, left his country before graduation and subsequently became interested in natural history.

This expedition was too hurried and with too few facilities for making collections to afford anything more than a very general insight into the character and relations of the several Cretaceous and Tertiary stages. It had shown conclusively that the dip of all the marine Tertiary beds is southward, except only as regards the Grand Gulf rocks, whose relations to the rest they had no opportunity of observing, since they are unrepresented in the Chickasawhay section, save by clays of which the equivalence was not then apparent.

Meanwhile, it had become apparent to the university trustees that in its present form the survey was in more than one respect a burden to the university, and, accordingly, at the legislative session of 1855–56, Governor McRae, in transmitting to the legislature the regular report of the trustees of the University of Mississippi, accompanied it by a special message, in which occur the following passages:

> The first portion of the trustees' report relates to the geological survey of the State geologist, and proposes the separation of this survey from the university, and asks that it may be taken charge of by the State as an independent work under the direction of the governor. The reasons for this are fully set forth in the report and may be recapitulated in brief as follows:
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> 1. The geological survey does not form a part of the course of instruction in the university and is not properly connected with the business of the institution.
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> 2. The duties of the State geologist, under the present arrangement, being partly as professor in the university, partly in the field survey, neither position can be fully or satisfactorily filled by him. Either the classes in his department must suffer in his absence or the survey in the field be neglected to give them proper attention.
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> 3. The funds of the university are not sufficient to justify in bestowing a portion of them on a work, however important and valuable to the State, that is not legitimately a portion of its business.
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> The appropriation by the State of $3,000 annually for the geological survey pays no more than the salary of the principal and assistant geologists, and the outfit and traveling expenses, apparatus, etc., amounting to as much more, have to be provided for out of the college funds. This is unjust to the university and the divided time of the State geologist between the university and the field operates injuriously both to the interests of the university and the State. I would not be understood by this, nor would the board of trustees, as casting any reflections upon the learned gentleman who now fills the place of State geologist, and whom they and myself believe to be well and highly qualified for the duties of that station, nor would we have it understood, and the board of trustees would not, that we detract in the slightest measure from the great interest and importance to the State of having a geological survey thoroughly and efficiently prosecuted. The object is to place it in the hands of the State and under the direction of her authority, where it properly belongs, and to have it vigorously prosecuted to completion at the earliest day. I therefore recommended to the legislature to place it in this position, and to provide the means necessary to accomplish this object. It is believed that an appropriation annually for three years of $6,000 will be sufficient to complete the entire work within that period.

The report of Professor Harper, herewith submitted, contains much valuable information, shows a high degree of sciencific attainment on his part, and gives evidence that when the work is completed it will be one of great value to the public. The present report is only preliminary and partial and is not designed for publication at this time, but is to be embodied and published in the general report, when completed.

The suggestion of the governor was not, however, favorably acted upon by the legislature. The matter was left without change, but with the understanding that a vigorous prosecution of the work should pave the way to more satisfactory legislation at a succeeding session.

After passing the winter at Oxford in the arrangement of the collections and preparations for analytical work Hilgard proceeded in April, 1856, to make a detailed exploration of the northeastern portion of the State, where the geological structure seemed most complex and varied. In the course of this expedition, made with the same outfit that had served the years before, he determined the character, stratigraphical relations, and limits of the Carboniferous, Cretaceous, and Tertiary beds of that part of the State, making extended collections especially of what was afterwards designated as the Ripley group of the Cretaceous by Conrad.

He also investigated closely the features and geological relations of the "Orange sand," now better known as the stratified drift, of the southwest, showing its derivation partly from northern sources, partly from the underlying formations, of which it contains the fossils, distinctly characterizing it as a Quaternary deposit of the drift age.

It having been clearly apparent to Professor Hilgard by this time that the survey would never maintain itself in public esteem on the basis of mineral discoveries, and that it must seek its main support in what services it might render to agriculture, he made a point of paying close attention to and recording the surface features,[1] vegetation, soils, the quality and supply of water, and especially the marls, which were found to occur in large supply and great variety. He also made a collection of plants which, although omitted from the subjects mentioned in the act creating the survey, he thought was essential toward the characterization of soils. In the prosecution of these studies the close connection between the surface vegetation and the underlying formations became so striking that he soon largely availed himself of the former in tracing out the limits of adjacent formations in searching for outcrops, etc.

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[1] No instrumental topographical work was ever done in connection with the Mississippi survey, partly because it was not provided for by law, partly because the continually recurring violent barometric changes during the working season rendered the use of the aneroid, so useful elsewhere, very unsatisfactory. The railroad levelings then available were, however, fully and extensively used and were excluded from the report of 1860 simply by the absolute need of brevity for the sake of reducing the expense of publication.

During the latter part of the season of 1856 Hilgard extended the detailed survey of the Cretaceous area as far south as Columbus; and thence, as the beginning of the rainy season rendered further field work unprofitable, drove across the country to Tuscaloosa, Alabama, in order to compare notes and consult with Tuomey, then State geologist of Alabama, and to gain an insight into the works of reference for Cretaceous and Tertiary paleontology. He was thus enabled to ascertain the relations of the "Tombigby (sic) sands" fossils to the "Rotten limestone," which he had thus far designated as Upper, but agreed henceforth to consider as *Middle* Cretaceous. Hilgard there also learned for the first time that Tuomey had found fossils—well preserved ammonites and several gasteropods—silicified in the "Lower Cretaceous" clays near Eutaw (or, rather, Finchs Ferry), Alabama, and it was agreed to designate this lower clayey stage, which in Mississippi had been found entirely barren of fossils, as the "Eutaw" group. Subsequently, prior publication gave precedence to Safford's name of "Coffee group" for the lower clays, and similarly Hilgard's "Tippah group" received from Conrad the prior name of "Ripley" for the uppermost Cretaceous.

Tuomey had at that time a portion of his second report in manuscript, and as, unfortunately, he died six months after the conference above noted, that report, which was posthumously edited by J. W. Mallet, does not show the latest phase of Tuomey's knowledge of the Cretaceous stages. As his collections were mostly destroyed during the war it is of interest to record here that almost all the Cretaceous fossils marked "Miss." in list "A," page 257 of that report, were from the "Tombigby sand" and the immediately overlying portion of the "Rotten limestone," in Lowndes County, Mississippi; the "*Ammonites Bi-Nodosus*" recorded in the same list, from Eutaw, Alabama, was considered by him as a "leading fossil" of the Lower Cretaceous clays. The specimens were all silicified and in excellent preservation.

Hilgard returned to Oxford in November across a country rendered almost impassable by copious rains, and found matters rapidly coming to a crisis at the university. Harper had been provided with a separate ambulance outfit, and had taken the field for a few weeks during the season of 1856 in the northwestern counties, but he seemed to be unable to keep away from Oxford for any length of time. Finally, the dissatisfaction of the board of trustees with his personal acts, in relation both to the survey and to the university, came to a head in November, 1856, when he was forced to resign. Hilgard was continued as assistant, with compensation increased to $1,500 a year, and was for the time being placed in charge of the survey, the office work of which he continued during the winter.

At the legislative session of 1856–57, however, Harper procured the passage of an act entitled "An act to provide for the printing of the Second Annual Report of the Agricultural and Geological Survey of the State, and for other purposes," approved January 31, 1857. The substantial provisions of this act were: First, the complete separation of the survey from all connection with the State University; second, that the survey should be prosecuted to completion according to the provisions of the previous act by a State geologist to be appointed by the governor and to receive a salary of $2,000 a year, to be furnished with such an outfit as may be necessary to be provided under the direction of the governor. "He shall also keep an exact account of his expenses in making said survey and submit the same to the examination of the governor, who shall issue his requisition upon the treasury for the amount, provided the sum shall not exceed $1,000 per annum." An appropriation of $1,200 was also made for the purchase of chemical apparatus for making analyses, and the State geologist was authorized to "occupy as a laboratory the two front rooms in the second story of the penitentiary building, and he shall be allowed the assistance of one convict, to be named by the inspectors, to aid him in keeping his apparatus in good order." It was also ordered "that 5,000 copies of Professor Harper's report be printed," and thereafter distributed in accordance with the provisions of the former act. The sum of $3,500 was appropriated for this publication, and Harper entered upon the office on March 1, 1857, but was voted compensation from the date of his resignation, in November preceding. The only work performed by him during his tenure of office under this act was the writing and publication of his report, which was done under his personal supervision at New York, although, like the former report, it bears the imprint of the State printer at Jackson. The circulation of the report through the State soon produced the inevitable result of discrediting its author to such an extent that toward the end of the year 1857 he was obliged to resign his office.

Shortly afterwards the appointment was tendered to Doctor Hilgard, who entered upon its duties early in 1858. At Jackson he found in the "two front rooms in the second story of the penitentiary," under the charge of the convict assistant, the outcome of the purchases made by Harper under the provision for the outfitting of an analytical laboratory. It consisted essentially of apparatus for elementary lectures in chemistry and an expensive microscope. The analytical balance was represented by a pair of apothecary's scales, etc. Under authority of the governor a portion of these articles were sold and the proceeds applied to the purchase of necessaries for analytical work, and under the same authority and by permission of the board of trustees of the State university, the whole was transferred to a front room in the university building at Oxford, which Hilgard fitted up as a laboratory, at a personal expense of $600, for the time being. By this evasion of the law framed under Harper's auspices (which was mandatory only in respect to the location of the "office," but not of the laboratory), the survey was again practically restored to its original connection with the university, without which the work could not be successfully carried on under so small an appropriation.

Hilgard took the field again in April with the same outfit—an ambulance with two mules and a negro driver—and, starting at the Ripley Cretaceous, devoted the season to the verification of a full section across the Tertiary areas, from north to south, including also the detailed examination of the fossiliferous localities near "Jackson" and "Vicksburg" stages in their most characteristic development.

In passing through the State Hilgard became painfully conscious of the fact that the survey had become extremely unpopular, as a consequence of Harper's incumbency and report, so much so that it was often very difficult to obtain information or even civil answers to inquiries. He felt that it would be necessary to throw off and purge the survey completely of the obnoxious antecedents if the appropriation was to be sustained at the coming session of the legislature. He therefore, after consulting with Governor McWillie, wrote a short Report upon the Condition of the Geological and Agricultural Survey of the State of Mississippi, of 22 octavo pages, which was printed by executive order and circulated prior to the session of the legislature in the winter of 1858–59. In this report he discussed—first, the need and advantages of a thorough geological and agricultural survey of the State; recited the causes of the slow progress and failure to satisfy the public, chief among which were inadequate appropriations and the incompetency of the late incumbent; also gave examples of what had been done in the matter in other States; and closed with a recommendation for the repeal of the law locating the headquarters of the survey in the State penitentiary and for the restoration of the geological assistantship, in connection with a more reasonably adequate appropriation.

The storm, however, broke loose when the legislature assembled. Those who had been instrumental in passing Harper's bill in 1857 were now most eager to have the survey "wiped out" to allay their soreness. A special committee was appointed to investigate the subject, and, without giving Hilgard a hearing, that committee promptly reported "A bill to abolish the geological and agricultural survey of the State." In presenting this report the chairman inveighed fiercely against the insolence exhibited in the report, above alluded to, and the attempt to "coerce the legislature by forestalling public opinion." The report to abolish would undoubtedly have been promptly adopted but for Hilgard's forcing a personal conference with the chairman, in which he presented to him the documents in the case and exhorted him to abolish the geologist, if he thought there was cause, but not the survey, the revival of which would be only a question of time. After this the "bill to abolish" was not called up, and the survey remained in without change during 1859.

The previous season's work having settled conclusively the succession of the several stages of the Tertiary and their prominent stratigraphical, lithological, and paleontological features, he devoted the season of 1859 to the filling in of details. He went more leisurely over the ground intended to have been covered by the previous joint expedition with Harper in 1855—namely, from the southern border of the Cretaceous area, near Columbus, down the Chickasawhay and Pascagoula valleys to the seacoast; along the coast to Pearl River, up that river to Columbia, Marion County, and thence across to the Mississippi; thence northward along the eastern border of the loess region to the belt marine Tertiaries, which he also examined more in detail between Jackson and Vicksburg. All these observations only served to largely confirm and complete his previous conclusions.

Returning from the field somewhat earlier than usual, Hilgard began the arrangement of materials for a report, to be presented at the legislative session of 1859–60, with a view to its publication and the procurement of a better endowment for the survey.

As an example of the work done by the survey he put up a collection of soils and marls, gathered during the three years' work, and had it on exhibition at the State fair held at Jackson in November. It excited a good deal of attention and newspaper comment, and gave a favorable turn to public opinion previously aroused by frequent communications of results made to agricultural and other papers of the State.

Outside of the fair work he carried on the work of analysis and writing, simultaneously and unremittingly, assisted by Prof. W. D. More, then holding the chair of English literature at the University of Mississippi. The manuscript was not nearly completed when the legislature convened in December, 1859, but there was enough to satisfy a special committee that it should be printed and that the working facilities should be enlarged.

The bill reported by that committee and afterwards passed with little difficulty by the legislature made no radical changes in the previous act defining the objects of the survey, but provided for the appointment of an assistant geologist at a salary of $1,500, enlarging the limits of the annual "expenses necessarily incurred in fitting up a chemical laboratory," and repealed the provision for keeping an office at Jackson, permitting the alternative of having it at Oxford.

Soon after the beginning of the Civil War the university faculty was dissolved and the survey discontinued, Professor Hilgard being first detailed by the governor to take charge of the State property at the university and afterwards appointed an agent of the niter bureau. In these and kindred capacities he served until the renewal of the work in 1866.

The mule team of the survey was sold under authority from the governor soon after the suspension of the survey. There being no legal mode of turning the proceeds into the State treasury, they remained in the custody of Doctor Hilgard in the form of notes, issued during the work by the State upon cotton pledged for their redemption and hence known as "cotton money." At the close of the war these notes were worthless and the survey left without means for repurchase. Subsequently, however, a suitable team was procured out of the appropriation for current expenditures.

Dr. George Little, formerly professor of natural sciences at Oakland College, near Rodney, Mississippi, was appointed assistant geologist in July, 1866, and shortly thereafter took the field for detailed exploration of the loess region from Rodney to its farthest point in Louisiana, the especial object being to ascertain its relation to the "coast Pliocene" or Port Hudson beds on the one hand, and to the southern equivalent of the "yellow loam" of Mississippi and Tennessee on the other. The general results of this exploration are briefly stated in Memoir No. 248 of the Smithsonian Contributions, page 4, namely, that the loess material gradually changes toward that of a noncalcareous and nonfossilferous hardpan or indurated silt, from a point about 8 miles below the Louisiana line, and seems also to thin out. No detailed report or field notes of this trip are on record.

In view of the difficulties and insecurity besetting the office of State geologist under the régime then existing in the State of Mississippi, in October, 1866, Doctor Hilgard accepted permanently the chair of chemistry at the university, and Doctor Little was then appointed State geologist. He took the field in the autumn of 1867, in order to reexplore the section of the Tertiary strata afforded by the Chickasawhay River, between Enterprise and Winchester. He descended the stream in a canoe, making numerous portages over shallow stretches. The result of this reexamination was simply a confirmation of the observations previously made by Hilgard, going by land, in 1859; of this exploration, also, no detailed record or report is on file.

No field work was done by Doctor Little in 1868, partly because by consent of the governor he was then acting as professor of geology and mineralogy at the university, in addition to the survey work in the laboratory and collection rooms.

In October, 1870, however, he definitely resigned the State geologistship for the professorship of geology and natural history in the university, and in order to prevent the survey from being either abolished or falling into the wrong hands, Hilgard again assumed its direction without additional compensation, it being understood that he should be under no obligation to take the field personally.

In November, 1868, the assistantship had been filled by the appointment of Dr. Eugene A. Smith, of Alabama, then just returned from his studies in Europe. Doctor Smith took hold of the work with energy, although the first duties were not of the most interesting character—namely, the farthest prosecution of the analyses of soils and marls selected so as to cover, as nearly as possible, all parts of the State. This work was carried on by him through the year 1869 and a portion of 1870.

In September of the latter year he took the field with the usual outfit of a two-mule ambulance and driver. There were then two regions in the State that had not been at all satisfactorily explored—one the belt northward of the Jackson area, of which only the portions lying in Neshoba and Lauderdale counties on the eastern border of the State, and a small area in Attala County, near the Central Railroad, had been somewhat minutely examined. This being the connecting link between the "northern lignitic" and calcareous marine stages, its examination was of especial interest, but at the same time a difficult task on account of the extreme variability of its materials and fossils and the scarcity of outcrops. The other comparatively unknown region was the great "Yazoo bottom," the geological exploration of which had become of especial interest in connection with the question of the age of the formations of the Gulf coast and Delta.

While the latter region was to be the chief objective point of the first expedition, Doctor Smith availed himself of the opportunity of observing a section across the older Tertiary in passing from Oxford to Yazoo City by way of the Pontotoc "flatwoods," Kosciusko, and Jackson.

He then descended into the Yazoo bottoms and traversed them, zigzagging from the river to the bluff from near Vicksburg to its head near Memphis. On this laborious and insalubrious trip he studied both the surface features of the great alluvial plain and the geological features of the deposits that form its substrata. A summary report of this important exploration was given by him at the Indianapolis meeting of the American Association for the Advancement of Science and was published in the volume of proceedings for 1871 (p. 252). The outcome of these observations is there summarily stated to have been that "the true river deposits" of any considerable thickness are mostly confined to narrow strips of land lying on both sides of the Mississippi and of the bayous and creeks and to ancient channels since filled up; while a large proportion of the superficial area of the bottom, including some of the most fertile lands, is derived from the clays of older formations into which these beds have been excavated. The equivalence of this older clay formation with that of the Port Hudson profile, already suggested, was thus verified.

Returning to Oxford early in December, Doctor Smith carried on the chemical work until the end of May, 1871, when he took the field again in order to trace across the State the "siliceous Claiborne" belt above referred to. His route lay from Leake County southeastward to the Alabama line, along the northern contact of the problematic "Red Hills" and yellow sandstones with the lignitic formation; then westward again in the more southerly portion of the belt, to the border of the Yazoo bottom (the "Mississippi bluff"). In this trip he traced the connection and established the equivalence of the ferruginous formation as a local feature, with the sandstones of Neshoba and Newton Counties, which again connect unequivocally with the characteristic "buhrstones" of Lauderdale.

In September, 1871, Doctor Smith resigned the assistantship to take the chair of geology and mineralogy in the University of Alabama, with which, through his efforts, the office of State geologist of the latter State was afterwards connected.

His successor in the assistantship of the Mississippi survey was Mr. R. H. Loughridge, of Texas, who had for some time previously acted as Hilgard's assistant in the chemical laboratory and subsequently as instructor in general chemistry. Mr. Loughridge prosecuted the chemical work of the survey during a part of the year 1872, while Doctor Hilgard was preparing for the elaboration of another report covering the work done since the publication of the report of 1860, when, by arbitrary ruling of the State auditor of public accounts, the survey appropriation was withheld, and thus in the autumn of 1872 the work was preemptorily stopped and has not been revived since, although the act of 1860 has never been legally rescinded. No provision for the publication of the results has ever been made by the State. The records and collections of the survey remained in custody of the University of Mississippi, and were left by Doctor Hilgard fully labeled as to locality and time of collection, with reference to the field notes, and to the name or designation under which the specimens of fossils appeared in the report of 1860.

Expenses.—Satisfactory statistics bearing upon the expenses of the survey are not available. So far as can be determined by the reading of the various acts establishing the survey and making the appropriations, they were approximately as follows:

By act of March 5, 1850, $3,000 a year for seven years	$21,000
By act of 1852, for museum	200
By act of 1854, for publication	2,500
By act of 1857, for laboratory	1,200
By act of 1860, for laboratory	545
By act of 1860, for publication	3,500
Total appropriations	$28,945

Salaries.—Under Professor Millington, the assistant geologists were paid $1,000 each, annually. Professor Hilgard, under Harper, received at first $1,000, which was later increased to $1,500 annually. Professor Harper's salary is given as having been $2,000 annually.

Publications.—The official reports of the several surveys were comprised under five reports and a circular announcing the resumption of work in 1866.

Wailes's report (the first of the Mississippi geological reports), of which the publication was provided for by the law of 1854, bears the imprint of E. Barksdale, State printer, 1854, but was actually printed at Philadelphia, where Wailes remained during the greater part of 1854 to superintend its passage through the press. The volume is an octavo of 371 pages, with 17 illustrations, partly of a historical character, partly referring to the cotton industry. Eight of these illustrate geological subjects, the most important being four plates of shells from the Jackson shell bed, named and described by Conrad. The report begins with a "historical outline," covering 125 pages; a treatise on the agriculture of the State, partly historical and dealing largely with cotton culture, followed by some analyses of marls, cotton, ashes, and mineral waters, and covering 81 pages; meteorological data, 12 pages; lists of fauna and flora, 46 pages; appendices, with documents, 25 pages. This summary is sufficiently indicative of the fact that Wailes was not and did not write as a specialist in any department. He made no attempt to classify the rocks he described otherwise than as Cretaceous, Tertiary, and Quaternary, and inferentially classed among the latter the sandstone of the Grand Gulf group, which is mentioned as overlying "diluvial gravel." He traced correctly the northern limit of the Grand Gulf rocks from the Mississippi, across Pearl River to Brandon, and described their occurrence in southwestern Mississippi.

The printing of Professor Harper's report was provided for by the act of 1857, which effected the separation of the survey from the university. The sum of $3,500 was voted for its publication. Concerning this Hilgard writes:

> Of this report it need only be said that it is a literary, linguistic, and scientific curiosity, and probably unique in official publications of its kind. It is the labored attempt of a socialist to show erudition and to compass the impossible feat of interpreting and discussing intelligently a considerable mass of observations mostly recorded by another, working on a totally different plane from himself. In making use of my field notes, which of course passed into his hands, the facts as well as the conclusions suffered such distortion that, but for the introduction of all the figures and diagrams given in my manuscript, I should have been unable in many cases to recognize my own work. It is thus that the "Orange sand" becomes in his hands "the Miocene formation," while what he saw of the Port Huron beds, as well as the Quarternary gravels, is referred to the Eocene. Shortly after the publication of the book I publicly disclaimed all responsibility for either facts or conclusions pretended to be based upon my work, since, although my name is nowhere mentioned in the volume, the innumerable errors would in the course of time be likely to be laid at my door.

The legislature of 1859 made an appropriation of $3,500 for printing Hilgard's report, "with such diagrams and maps as the governor shall deem necessary for its illustration;" and "it is hereby especially enjoined upon his excellency, in the publication of said book, to have the same performed at the South, if the same can be done at an advance of 10 per cent upon the cost of its publication at the North." The latter clause was a characteristic sign of the times. The act was approved by the governor February 10, 1860.

It was soon and easily ascertained that the 5,000 copies of the volume could not be printed anywhere at the South at an advance of 10 per cent on New York prices, but Governor Pettus declared that he would not allow it to go North under any circumstances, even if it had to remain unprinted. The estimates prepared by Mr. E. Barksdale, the State printer, showed that to do the work in his office would cost over $4,000 at the lowest estimate placed upon the uncompleted manuscript. Finally, Mr. Barksdale proposed that if Hilgard would be responsible for $250 of the excess of cost over the amount allowed by the State, he would cover the rest. This proposition was accepted, and the governor relented so far as to allow the map, which could not be furnished by any southern establishment, to be prepared by the Coltons of New York; the other plates were prepared at New Orleans.

The printing was begun at Jackson in May, 1860. The latter parts of the report were largely written while the first portion was passing through the press, but several forms were not yet in print when, in August, imperative business called Doctor Hilgard to Europe, and the work of seeing the report through the press fell upon Dr. W. D. Moore.

On Hilgard's return from Europe in November, 1860, he found the report in print, and shortly afterwards it was shipped to St. Louis for binding. The political events which soon afterward convulsed the country prevented the return of the bound edition to Mississippi. It remained warehoused in the binder's hands during the entire war between the States, and it was not until 1865 that measures were taken for its recovery. The war and the "12 months thereafter" having expired, the survey was revived *ipso facto* on the basis of the act of 1860, and Hilgard found the State printer, Mr. E. Barksdale, determined to carry out to the letter his agreement in respect to the publication of the report, thus likewise reviving his obligation to contribute $250 toward the payment of its cost, which, under the conditions then existing, was a heavy tax. The edition was received at Jackson early in 1866 and thence distributed according to the following law:

An act to regulate the distribution of the reports on the geology and agriculture of the State of Mississippi.

SECTION 1. *Be it enacted by the legislature of the State of Mississippi,* That 2,500 of Doctor Hilgard's reports on the geology and agriculture of the State shall be distributed by the secretary of state to the counties and public institutions in accordance with the provisions of the act regulating the distribution of the preceding report, except so far as relate to the State University.

SEC. 2. *Be it further enacted,* That it shall be the duty of the secretary of state to deposit at the State University 250 copies of said report for the use of the institution and for distribution to and exchange with scientific and literary men and institutions by the librarian of the university, under the direction of the faculty.

SEC. 3. *Be it further enacted,* That the copies not distributed in accordance with the provisions of the preceding section shall remain deposited in the capital, subject to the control of the secretary of state, who shall have authority to issue one copy gratuitously to any citizen of the State making application for the same, and to citizens of other States upon the payment of $1 per copy, or in exchange for works of similar character, to be deposited in the State library.

SEC. 4. *Be it further enacted,* That this act shall take effect and be in force from and after its passage.

Approved, February 18, 1867.

Benefits.—The benefits of the surveys under direction of Doctor Hilgard are summarized by him:

In this report I undertook to separate, as far as possible, the purely scientific part from that bearing directly upon practical points, in order to render the latter as accessible to unscientific readers as the nature of the case permitted, while at the same time giving scientific discussion full swing in its proper place. This was the more necessary as my predecessor's reports had been sharply criticized in this respect; and I think the result has justified my judgment in the premises. The volume is thus divided nearly evenly between a "geological" and "agricultural" portion; the former giving, under the special heading of "useful materials," the technically important features of each formation, after its geological characters have been discussed. In the agricultural portion it seemed needful at the time to give by way of introduction, a brief discussion of the principles of agricultural chemistry, then but little understood by the general public; and accordingly, 50 pages are given to this subject and discussed with reference to the agricultuarl practice of the State. In the special or descriptive portion of the agricultural report the State is divided into "regions" characterized by more or less uniformity of soil and surface features; and each is considered in detail with respect to all natural features bearing on agricultural pursuits, special attention being given to the nature of the soils as shown by their vegetation and analysis.

In the latter respect I departed pointedly from the then prevailing opinions, by which soil analysis was held to be practically useless. My exploration of the State had shown me such intimate connection between the natural vegetation and the varying chemical nature of the underlying strata that have contributed to soil formation, as to greatly encourage the belief that definite results could be eliminated from the discussion of a considerable number of analyses, of soils carefully observed and classified with respect both to their origin and the natural vegetation, and a comparison of these data with the results of cultivation; and that thus it would become possible, after all, to do what Liebig originally expected could be done, viz, to predict measurably the behavior of soils in cultivation from their chemical composition. To what extent this expectation has been fufilled, is hardly apparent from the very limited number of analyses which my unaided work was able to furnish for the report of 1860. But lights then obtained encouraged me to persevere in the same line of investigation, in the face of much adverse criticism, when wider opportunities presented themselves afterwards. By the aid of these I think I may fairly claim that the right of soil analysis to be considered as an essential and often decisive factor in the *a priori* estimation of the cultural value of virgin soils, has been well established alongside of the limitations imposed by physical and climatic conditions and by previous invention of culture.[1]

With the recognition of these facts the importance of agricultural surveys to the population especially of the newer states and territories becomes sufficiently obvious to command at least the same attention as those investigations directed specially to the recognition of the geological and mineral resources of the same regions; and the "classification of lands," provided for under the law creating the United States Geological Survey, assumes a new and more pressing significance. Even apart from any special investigations of soil composition, the right of the agricultural interests to at least a good intelligent and intelligible description of the surface features of a region, given with respect to its agricultural capabilities and its attractions for settlers, can hardly be denied. With the additional possibilities opened by the intelligent application of soil investigation, there is no excuse for the neglect, sometimes almost absolute, with which this branch of the public surveys has thus far been treated by those charged with their execution.

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[1] For a more extended exemplification and discussion of the nature and utility of such work, see the Report on Cotton Production in the United States, vols. 5 and 6 of the Reports of the Tenth Census; also Amer. Journ. Sci., December, 1872, p. 434; also issue for September, p. 133.

Dr. David D. Owen was, among the older American geologists, the one who most steadily kept the agricultural interests in view and gave them prominence in his researches and reports; and while my personal intercourse with him predisposed me to follow his example in this respect, my further experience has only served to strengthen my conviction that a reasonable proportion of attention given to agricultural work would effectually smooth the path of our public surveys, whose fate is forever trembling in the balance at each reassembling of the legislative bodies upon which their continued endowment depends and by whose country members their utility is constantly called in question. No such question was raised in Mississippi after the publication of my report for 1860, and legislative appropriations for substantially similar work done by me on behalf of agriculture have since been liberally maintained in California, despite the conspicious disfavor with which the geological survey of that State has for 12 years past been regarded by the public. Had that survey been adapted to the legitimate needs of the State, by proper diligence in the pursuit of its agricultural side, the discontinuance of the work would never have been carried through the legislature.

As a striking exemplification of the change wrought in public sentiment by the energetic prosecution of agricultural survey work, I may quote the action taken at the called session of the Legislature of Mississippi in August, 1861. Under the terrible stress brought to bear on the State even then by the impending conflict, it would have been natural to expect the complete extinction of the appropriation for the survey work. Instead of this, an act was passed suspending the appropriation for the geological survey "until the close of the war and for 12 months thereafter; except the sum of $1,250 per annum, which shall be applied to the payment of the salary of the State geologist, and the purchase of such chemicals as may be necessary to carry on the analysis of soils, minerals, and mineral waters and to enable him to preserve the apparatus, analyses, and other property of the State connected with said survey."

This appropriation was actually maintained during the entire struggle of the Confederacy, and, so far as the vicissitudes of war permitted, the chemical work (and even some field work) was continued by me during the same time. The scarcity of salt suggested the utilzation of some of the saline waters and efflorescences so common in the southern part of the State, and some 40 (unpublished) analyses of such saline mixtures are on record. I made an official report on the subject to Governor Pettus, dated June 9, 1862. I also made a special exploration on the several limestone caves of the State with a view to the discovery of nitrous earths; but from the fact that these caves are all traversed by lively streams. I found nowhere a sufficient accumulation of nitrates to render exploitation useful.

MISSOURI.[1]

FIRST SURVEY UNDER GEORGE C. SWALLOW, 1853–1862.

Organization.—About the earliest record available of official action on the part of the State of Missouri in the direction of a geological survey is given in the message of Gov. Lilburn W. Boggs to the tenth general assembly, in 1833. In this he recommended an

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[1] See also Geological Survey of Missouri, Journal of Geology, vol. 2, 1894, pp. 207–221, and Trans. St. Louis Acad. Sci., vol. 4, 1878–86, pp. 611–624.

ARTHUR WINSLOW, 1889-94

GARLAND CARR BROADHEAD, 1873-75

RAPHAEL PUMPELLY, 1872-73.

STATE GEOLOGISTS OF MISSOURI.

appropriation for a geological survey as a part of a general system of internal improvement.

Apparently as a result of the spirit prompting this recommendation, surveys of the Meramec, the Salt, the North, Grand, and Osage rivers were started, under a board of internal improvements, and the geological examination of the Osage River was made under Dr. Henry King, president of the Western Academy of Natural Sciences. After this the matter of investigation by the State seems to have fallen into neglect for several years.

In October, 1846, at a convention held in Springfield in the interest of internal improvement a memorial was framed to the general assembly, in which special stress was laid upon the value of the development of the mineral resources of the State.

In the message of Gov. John C. Edwards to the assembly in the same year the subject of a geological survey was again recommended for consideration. The matter was referred to the committee on internal improvement, of which Dewitt C. Ballou was chairman. In a report of eight pages this committee strongly advised the inauguration of such an undertaking. No immediate action, however, followed, and at the session of the general assembly of 1848 a memorial of 13 pages was presented from the Historical and Philosophical Society of Missouri, again inviting the attention of the legislature to the matter. The immediate effect of this was another memorial from the legislature to Congress urging that the National Government have made a geological survey of the State. Nothing seems to have resulted from this memorial, and in the following year (1850) Gov. Austin A. King, in his message to the sixteenth general assembly, again urged the importance of attending to these matters. Again nothing immediate seems to have been done, but the matter continued to be agitated, and during the session of the legislature of 1853 an act creating the first geological survey of the State was passed and approved.

The following is the text of this act:

An act to provide for a geological and mineralogical survey of the State.

Be it enacted by the General Assembly of the State of Missouri, as follows:

1. The governor of this State is hereby authorized and required, as soon as may be after the passage of this act, to appoint a State geologist, who shall be a person of competent scientific and practical knowledge of the sciences of geology and mineralogy; and the said State geologist shall, by and with the consent of the governor, appoint any number of suitable persons, not exceeding four, to assist him in the discharge of his duties, who shall be skillful, analytical, and experimental chemists; and may appoint such other subordinate assistants, as he may deem necessary.

2. It shall be the duty of the said State geologist, and his said principal assistants, as soon as may be practicable after their appointment, to commence

and carry on with as much expedition and dispatch, as may be consistent with minuteness and accuracy, with a view to determine the order, succession, arrangement, relative position, dip, or inclination, and comparative magnitude of the several strata, or geological formations, within this State; and to discover and examine all beds or deposits or ore, coal, marls, and such other mineral substances, and mineral waters, as may be useful or valuable, and to perform such other duties as may be necessary to make a full and complete geological and mineralogical survey of the State.

3. It shall be the duty of the said assistants to make full and complete examinations, assays, and analyses of all rocks, ores, soils, or other substances, as may be submitted to them by the State geologist for the purpose, and to furnish him with a detailed and complete account of the results so obtained.

4. It shall be the duty of the said geologist on or before the 1st day of December in each and every year during the time necessarily occupied by said survey, to make an annual report of the progress of said survey, accompanied with such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same, to the secretary of state, who shall lay such report before the legislature.

5. It shall be the duty of said State geologist to cause to be represented on the map of the State, by color and other appropriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances discovered; and on the completion of the survey to complete a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

6. It shall be the duty of the State geologist to forward to the secretary of state from time to time, during the progress of the survey, such specimens in triplicate of the rocks, ores, coals, soils, fossils, and other mineral substances discovered and examined, and may be proper and necessary to form a complete cabinet collection of specimens of the geology and mineralogy of the State; and the said secretary shall cause one set thereof to be deposited, in proper order, in some convenient room in the State capitol, there to be preserved for public inspection, and another set with the State university, and another set with the city of St. Louis, to be deposited by said city in some convenient place or with some public institution in that city for public inspection.

7. For the purpose of carrying into effect the provisions of this act the sum of $10,000 is hereby annually appropriated, for the term of two years, to be expended under the direction of the governor: *Provided, however,* That the salaries of the said State geologist and his assistants shall not commence until they have been entered upon the execution of their duties; and upon presentation by the said State geologist of the proper vouchers, the auditor of public accounts is hereby required to draw his warrant on the treasurer for the amount of the cost of any chemical apparatus or other outfit, deemed necessary by said State geologist, and also for the amount of the quarterly pay of the said State geologist and his assistants, on presentation of the proper vouchers, by said State geologist, and upon the order of the governor, who shall be satisfied that the services for which such pay shall be demanded have been performed; *Provided,* That the amount of such cost and pay shall not, in any one year, exceed the amount herein appropriated.

8. The said State geologist and his principal assistants, before entering upon the discharge of their duties, shall each take an oath before some judge or justice of the peace faithfully to perform all the services required of them under

this act, and to abstain from all pecuniary speculations for themselves or others in the objects of their survey during its progress.

9. The annual salary of said State geologist shall not exceed $3,000; the annual salary of the principal assistants shall not exceed $1,500; and the pay of subordinate assistants or servants shall not exceed $1 per day for every day of actual service.

10. Before appointing said State geologist, as provided for in the first section of this act, the governor is requested to correspond with men of science on the subject, with the view of procuring the services of a person entirely suitable and competent.

11. This act to take effect from its passage.

Approved, February 24, 1853.

This survey, it will be noted, had no connection with other institutions, although the State geologist was, during a part of his term of service, professor of geology in the State University. It was sustained by the regular annual appropriations made by order of the legislature.

Administration.—Under the act of 1853 Prof. G. C. Swallow, who had been engaged in teaching in Maine, was made State geologist; Prof. A. Little, of St. Louis, chemist; and R. B. Price, of Brunswick, Missouri, draftsman. Subsequently, B. F. Shumard, of Louisville, Kentucky, was appointed paleontologist and assistant geologist. In 1854 F. B. Meek was commissioned assistant geologist; in 1857 G. C. Broadhead and Henry Engelmann received like commissions; and in 1858 Dr. J. G. Norwood was appointed assistant geologist. Mr. R. B. Price, resigning in 1858, his position was filled by the appointment of H. A. Ulffers, who served also as assistant geologist. Mr. C. Gilbert Wheeler was assistant geologist from 1860 to 1861.

In addition to these, R. B. Price, Fred. Bass, F. Hawn, Warren Hough, Edward Harrison, and Daniel Crosby are mentioned in the annual report as having rendered assistance. All the assistants were, as noted in the law, appointed by the State geologist, by and with the consent of the governor.

The salary received by the State geologist was at the rate of $3,000 a year and the assistants $1,000 and $1,500 a year.

The aim of the survey, as stated in the first report, was to make (1) an outline of the general geology of the whole State; (2) a general view of the mineral wealth of the mining district; (3) an exposition of the agricultural and manufacturing resources of the State; and (4) reports in detail of as many counties as possible.

The character of the work was mainly preliminary. It aimed to mark down on accurate maps the boundaries of the geological formations, the limits of the prairie and timber, mineral localities, and all matters necessary to form a geographical as well as geological map. Sections were corrected and grouped, and minerals, fossils, rocks, ores, and mineral waters collected, and also soils.

Besides noting the geology, the members of the survey were expected, when convenient, to make botanical and zoological collections. There were, as a rule, two parties in the field, with camp equipage, horses, etc., the property of the State. The office and headquarters of the survey were in rooms of the State University at Columbia.

Concerning the work of this survey Winslow remarks:

> Reviewing briefly this work of the geological survey, we must recognize as remarkable and excellent the classification of the rocks which are involved, as well as the general accuracy with which the distribution of the formations was defined, especially when the short time is considered. Under the control of Hall's new classification and nomenclature published in 1843, though undoubtedly assisted, yet not mislead by Owen's results, Swallow and his assistant established a table of formations and outlined a geographical map of the State, which remains to this date unchanged in its main features.

The law required that the collections should be made in triplicate, one set of which should go to the State University, one to the city of St. Louis, and one to be deposited in some convenient room in the capitol. The Civil War interfered and the collections, though made, were not distributed, the specimens for the most part remaining in boxes until 1884, when they were unpacked and partly arranged in the museum of the State University.

Expenses.—The total cost of the survey during the nine years of its existence was $105,000.

Publications.—Five reports of progress were issued, dated 1853, 1854, 1856, 1859, and 1860, respectively. Of these only the second, comprising 447 pages, contained anything of geological importance, and is the one commonly known as Swallow's report on the geology of Missouri. The others are all brief and partly administrative. The annual reports were distributed through the members of the legislature and by the geologist.

SECOND SURVEY UNDER ALBERT D. HAGER, 1870–1871.

Organization.—The survey under Professor Swallow came to an end, as noted, in 1862, owing to the disorganized condition of the country caused by the Civil War. The matter was not, however, long allowed to remain dormant, and even before the close of the war a James McKenzie presented a petition to the legislature, the object of which was to secure the publication of information concerning the resources of the State for foreign distribution.

In the report of the corresponding secretary of the board of agriculture for 1865, the importance of a scientific survey was dwelt on, but no definite recommendations made. In the report of the secretary of the same organization, for 1866, the need of geological work again found expression, and at the meeting of the board of agriculture in December, 1867, a resolution was passed to memorialize the general assembly to appoint a State geologist.

The first movement on the part of the legislature, in response to these solicitations, was the bill passed in 1866 authorizing Professor Swallow and L. D. Morse (or Moore) to publish the manuscripts of the first geological survey. This idea was, however, abandoned on account of the expense.

In 1867 a memorial was presented to the legislature from the St. Louis Academy of Sciences advocating the reestablishment of the geological survey and calling attention to the loss which would result if no provisions were made for the publication of results of the work done by the previous organization.

Nothing seems to have been done until Gov. J. W. McClurg, in his message of January, 1868, devoted considerable space to a consideration of the resources of the State, and paid tribute to the value of the Swallow report, and recommended the publication of further detailed information. The effect of this message was immediate, and on March 24 an act was passed creating the second geological survey.

The provisions of this act were in the main the same as those of the act creating the first survey, differing, however, in some particulars, and mainly in that the bureau was placed under the control of a board of managers of nine members, whereas, by the provisions of the first act the State geologist was subject to the direction of the governor alone. The following is the text of this act:

An act to establish a mining, metallurgical, and geological bureau for the State of Missouri, and to provide for its support and management, and to authorize a geological survey.

Be it enacted by the General Assembly of the State of Missouri, as follows:

SECTION 1. There is hereby created and established a bureau of the mines, metallurgy, and geology for the State of Missouri, and the same shall be in the charge and under the control of a board of managers, consisting of the governor, who shall be the president of the board, and one member from each congressional district, who shall be appointed by the governor, and hold their offices for the term of four years, and until their successors are appointed and confirmed.

SEC. 2. The governor shall, as soon as the board of managers is constituted as provided in the preceding section of this act, and with the advice and consent of said board, appoint a fit and competent person as State geologist, and said State geologist may appoint, subject to the approval of the board of managers one assistant State geologist, who shall be a skillful, analytical, and practical chemist, to assist him in the discharge of his duties, and the said State geologist may employ such other subordinate assistants as may be found necessary.

SEC. 3. It shall be the duty of the said State geologist and his assistant, as soon as may be practicable after their appointment, to commence and carry on, with as much expedition as may be consistent with minuteness and accuracy, a thorough mineralogical and geological survey of this State, and determine the extent, value, order, succession, arrangement, relative position, dip or inclination, and comparative magnitude of the mineral deposits and the several strata or geological formations within this State, and also determine the extent of the agricultural, horticultural, and vine lands, and their adaptability to the varied products of the soil, and also to determine the extent and capacity of the water powers of the various streams, and shall also make full and complete assays and analyses as they may deem necessary, of all minerals, soils, and other substances necessary for a complete and satisfactory report of the material discovered and so treated.

Sec. 4. It shall be the duty of the said State geologist to make a monthly summary of his work, and forward the same to the president of the board of managers for publication, and shall also, on or before the 1st day of December in each and every year during the time necessarily occupied by said survey, to make a full report of the progress of said survey during the preceding year, which shall be accompanied by such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same, and deliver the same to the aforesaid president.

Sec. 5. It shall be the duty of said State geologist, upon the completion of the survey, to represent, or cause to be represented, upon proper maps of the State, by distinctive lines, marks, and appropriate colors, the area and magnitude of the various beds of different minerals, valuable rocks, marls, agricultural, vine, and horticultural lands, and the various interesting or anomalous stratified rocks discovered, and the water powers aforesaid, and shall accompany the same with a complete memoir of all the minerals, rocks, agricultural, vine, and farming lands thus delineated, as well as the watercourses required by this act to (be) examined; and he shall embrace within such memoir a full, entire, and accurate account of the leading discoveries made in the State, and also a glossary of the scientific terms used in the report; and the said report, so made, when being completed, shall be deposited with the president of the board of managers.

Sec. 6. It shall be the duty of the State geologist to forward to the president of the board of managers, from time to time during the progress of the survey, such specimens, in triplicate, of the rocks, ores, coals, fossils, and other mineral substances examined, properly labeled, giving the names of such specimens and localities from which they were taken, for the purpose of forming a complete cabinet of specimens of the mineralogy and geology of the State. One set of said specimens shall be placed in the school of mines and metallurgy whenever the same shall be established; one set shall be placed in the State University; and the other shall be preserved in such manner as the board of managers may direct; and the said specimens shall be open to public inspection at all reasonable hours, under such regulations as are necessary for their proper care and preservation.

Sec. 7. The State geologist and his assistant, before entering upon the discharge of their duties, shall each take an oath before some officer of this State qualified to administer oaths, that they will honestly, faithfully, and fairly perform all the duties required of them by this act, to the best of their abilities, and that they will not permit any person to have access to any of their books or papers, or communicate their contents to any person or persons; and that they will not disclose or make public any mine or valuable deposit, otherwise than in their official reports to the board of managers, and that they will abstain from all speculations in their own behalf, or in behalf of others, during the progress of such survey and in relation thereto.

SEC. 8. The annual salary of the State geologist shall not exceed $3,000; the annual salary of the assistant shall not exceed $2,000, and the pay of the subordinate assistants shall not exceed, for each of them, the sum of $1.50 per day for each day employed.

SEC. 9. The board of managers of the bureau herein provided for shall have a superintending control over the surveys and reports contemplated by this act; shall have power to make yearly agreements with the State geologist and his assistants as to the amount of their salaries; to appoint a committee of their body to examine, audit, and allow all necessary expenses of such survey as they occur, and to certify the same to the governor; to remove from office, for cause, the said State geologist or any of his assistants; and so soon as possible after their organization under this act, should they deem the best interests of the State to require it, they shall provide for the establishment, at the most accessible point in the State, of an office for assayer of ores. And when so established, the governor of the State, by, and with the consent of said board, shall appoint an assayer for such office, whose duties shall be prescribed by the board of managers, who shall by contract determine the amount of salary, which in no case shall exceed the sum of $2,000 per year.

SEC. 10. The said board of managers shall demand and take possession of all the geological reports of this State, published and unpublished, instruments, implements, and all other paraphernalia which were used in connection with the geological surveys of this State by the former geologist employed by the State. And all persons now in possession of the same are hereby authorized and required to turn the same over to the president of the board of managers of the bureau herein established, and when received, the said board shall have power to turn the same over to the State geologist, or make such other disposition of them as they may deem the best interest of the State demand.

SEC. 11. The president of the said board of managers of the said bureau shall receive all the reports of the State geologist contemplated by this act; shall lay the same before the board of managers for their consideration and approval, at their annual meeting, to be held at any time, at the discretion of the president, before the meeting of the general assembly; and after the day fixed by this act when the State geologist is required to make his annual report, and at such meeting the president shall lay before the said board an accurate account of all expenditures incurred in prosecuting the objects for which this bureau has been created, all of which, after the action of the board thereon, shall be laid before the general assembly at the first following session by the president.

SEC. 12. The board of managers herein provided for shall be allowed, as a full compensation, their necessary expenses whilst attending to any of the duties required of them by this act, the accounts therefor to be made out under oath and filed with the State auditor, and the pay of the State geologist and his assistant shall be out of the appropriations applicable to the payment of other civil officers of the State.

SEC. 13. The sum of $7,500 is hereby appropriated out of any money in the State treasury not otherwise appropriated to defray the general expenses of the bureau created by this act, and no larger amount shall be expended for such purposes in any one year. The president of the board of managers is hereby authorized to certify to the State auditor, from time to time, the sums of money required to pay the salaries of the State geologist and his assistant and for the general expenses of the bureau, and on receiving such certificates the auditor shall draw his warrant on the treasurer of the State for the requisite amounts in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the account of the proper appropriation.

SEC. 14. This act shall take effect and be in force from and after its passage.

Approved, March 24, 1870.

Administration.—Under the act of 1870 Albert D. Hager, of Vermont, and at one time connected with the survey of that State under Dr. Edward Hitchcock, was appointed by the board State geologist, and headquarters were established at St. Louis. He held this position only until August, 1871, when Dr. Joseph G. Norwood was placed temporarily in charge and held office until November 25 of the same year. With Doctor Norwood were appointed G. C. Broadhead and C. M. Litton, assistants.

The board of managers for this survey were elected for two years and the State geologist for an indefinite period. The latter was authorized to appoint one assistant and one chemist and such other assistants as the board might deem necessary. The members of the board themselves received no salary, but were allowed necessary expenses for traveling, etc., and a secretary, who was paid $50 per month.

By law the salary of the State geologist was not to exceed $3,000 a year and that of the assistants not to exceed $2,000; the subordinates to be paid at the rate of $1.50 per day so long as employed.

Expenses.—The total appropriations for this survey were $12,500.

Publication.—Mr. Hager published but one report of progress—a pamphlet of 21 pages, in which were briefly noted the chief minerals and building stones of the State.

THIRD SURVEY UNDER R. PUMPELLY AND GEORGE C. BROADHEAD, 1872–1874.

The law of 1870 being found unsatisfactory it was amended in 1871 by the passage of the following act. It will be noted that among other changes, the board of managers was reduced from 10 (the governor and one for each congressional district) to 5.

An act to provide for a bureau of geology and mines to complete the geological survey of the State of Missouri.

Be it enacted by the General Assembly of the State of Missouri, as follows:

SECTION 1. There is hereby created and established a bureau of geology and mines for the State of Missouri, which shall be under the direction and in charge of a board of managers, which shall consist of the governor, who shall be president of the board, and four citizens from the State at large, who shall be appointed by the governor, shall hold their office for the term of two years and until their successors are appointed and qualified.

SEC. 2. As soon as the board of managers is organized, as provided in the preceding section, the present State geologist may appoint, subject to the approval of the board of managers, one assistant paleontologist and geologist and one assistant chemist to assist him in the discharge of his duties; and said State geologist may employ such subordinates and laborers as may be deemed necessary by the board: *Provided*, The whole expenditure of the board shall not exceed the sum hereinafter appropriated.

SEC. 3. It shall be the duty of the State geologist and his assistants, under the instructions and directions of the board of managers, to carry on and complete the geological survey of the State already begun, with a view to determine the order, succession, arrangement, relation, position, dip, or inclination and comparative magnitude of the several strata or geological formations within this State, and to discover and examine all beds or deposits of ore, coal, marls, and such other mineral substances and mineral waters as may be useful or valuable; make full and complete examinations, assays, and analyses of such rocks, clays, marls, ores, and other substances as may indicate useful results, and to perform such other duties as may be necessary to make a full and complete geological and mineralogical survey of the State.

SEC. 4. It shall be the duty of the State geologist to make, or cause to be made, a detailed report of each county as soon as the survey thereof shall be completed. Each county report shall be accompanied by an accurate map and section of the county, on which shall be represented by colors and other appropriate means, the various areas occupied by the prairie, timber and bottom lands, and by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances discovered; and on the completion of the survey of the State he shall make complete report of the geology and mineralogy of each county, comprising a full account of the discoveries made, and each of such reports shall be delivered to the board of managers as soon as completed.

SEC. 5. It shall be the duty of the State geologist to collect, in triplicate, all rocks, ores, coals, fossils, and such other mineral substances discovered as may be necessary to form a complete cabinet collection of the geology and mineralogy of the State.

SEC. 6. It shall be the duty of the board of managers to report to the general assembly, on the first week of each session, the progress and condition of the survey, a detailed account of all moneys spent, and all such reports of the State geologist and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

SEC. 7. It shall be the duty of said board to collect and take possession of all materials accumulated by the previous surveys, whether reports, maps, sections, collections, instruments, or other property belonging to the State; and all persons now in possession of the same shall deliver them up to the order of the president of the board of managers.

SEC. 8. It shall be the duty of the board to determine, as far as may be, what work has been done by each one employed in previous surveys, the character of the work done by each, the condition of such work, how much of the State has been actually surveyed, and how much of said work may be made available in completing the survey of the State, and embody the same in their first report to the general assembly.

SEC. 9. The board may make such by-laws and regulations for the government and control of its own meetings and the labors of the State geologist and his assistants as may be deemed necessary. It may appoint officers and committees to audit and allow accounts and look after particular departments of the work, and discharge such other duties as may be necessary to carry on the objects of this bureau.

SEC. 10. As a full compensation for the members of the board of managers they shall be allowed their necessary expenses while attending to the duties assigned them by this act. The board shall fix the salaries of the State geologist, not to exceed $3,000 per annum of actual service, and of all others employed in the work of the survey.

Sec. 11. All accounts for salaries and expenses shall be made under oath, and certified by the board and filed with the auditor of the State; and the pay of the State geologist and his assistants shall be made out of the appropriation made for civil officers of the State.

Sec. 12. The sum of $5,000 is hereby annually appropriated, out of any money in the treasury not otherwise appropriated, to defray the incidental expenses of the bureau created by this act and the geological survey, and no more than this amount shall be thus expended in any one year.

Sec. 13. The board of managers shall have the general management of the survey, and have full power to remove the State geologist or any of his assistants, and appoint their successors when deemed necessary for the good of the work entrusted to them.

Sec. 14. It shall be the duty of the board to cause the geological collections made previous to the year 1870 to be distributed in accordance with the laws under which those collections were made. except the one collected for the State capitol, which shall be given to the School of Mines and Metallurgy, and all subsequent collections made in triplicate shall be given, one suite to the State University, one to the State School of Mines and Metallurgy, and one to the city of St. Louis, which shall be deposited by the authorities of that city in some institution for the advancement of science or general education.

Sec. 15. The president of the board shall, from time to time. certify to the State auditor the sums of money required to pay the salaries of the State geologist and his assistants, and for the incidental expenses of the bureau; and on receiving such certificates the auditor of State shall draw his warrant on the treasurer of the State for the requisite amounts in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the accounts of the proper appropriation.

Sec. 16. The entire expenses of carrying out the provisions of this act shall not exceed in any one year the sum of $10,000.

Sec. 17. The State geologist and his assistant, before entering upon the discharge of their duties, shall each take an oath before some officer of this State qualified to administer oaths, that they will honestly, faithfully, and fairly perform the duties required of them by this act to the best of their ability, and that they will not permit any person to have access to any of their books or papers. or communicate their contents to any person or persons, and that they will not disclose or make public any mine or valuable deposit, other than in their official reports (except to the owner or owners of the land surveyed), and that they will abstain from all speculations in their own behalf, or in the behalf of others, during the progress of such survey and in relation thereto.

Sec. 18. An act entitled "An act to establish a mining, metallurgical, and geological bureau for the State of Missouri, and to provide for its support and management, and to authorize a geological survey," approved March 24, 1870, and all other acts and parts of acts inconsistent with the act are hereby repealed.

Sec. 19. This act shall take effect and be in force from and after its passage.
Approved March 18, 1871.

Administration.—Under this act Raphael Pumpelly, of New York, was appointed State geologist, with G. C. Broadhead, W. B. Potter,

J. R. Gage, Adolph Schmidt, W. E. Guy, C. J. Norwood, and Alexander Leonard, assistant geologists, and Regis Chauvenet, chemist.

During Pumpelly's management of the survey the board of managers consisted of Gov. B. Gratz Brown, *ex officio* president; Mr. Edwin Harrison, Prof. Sylvester Waterhouse, Mr. Forrest Shepherd, and Gen. J. H. Hammond. Governor Brown was succeeded in 1873 by Gov. Silas Woodson. Professor Waterhouse and General Hammond resigned in the summer of 1872, and their places were filled by A. W. Morris and M. L. Brown.

The plan of the work adopted by Pumpelly recognized two classes of investigation: One was the study of the general stratigraphic geology of the State; the other the study of the distribution and manner of occurrence of the various important mineral deposits, which latter investigation he put in charge of specialists or men whose previous experience had proven them especially adapted to the work.

In harmony with this plan the work on the general stratigraphy was divided into five departments; that is, a survey of the northwest, a survey of the southwest, a survey of the northeast, a survey of the southeast, and a survey of the porphyry regions of the southeast. The work relating to economic geology was divided into three departments—namely, a department of iron ores and metallurgy, a department of ores other than iron, a department of fuels and construction materials other than iron and wood.

With the retirement of Mr. Pumpelly, Mr. G. C. Broadhead was elected State geologist, assuming charge in July, 1873. Dr. A. Schmidt and C. J. Norwood remained as assistant geologists; Regis Chauvenet, chemist; Messrs. Alexander Leonard, P. N. Moore, H. H. West, T. J. Caldwell, and C. Heinrichs, assistants.

The policy of the Pumpelly survey was continued under Broadhead's administration, though a larger proportion of time was devoted to the preparation of county reports. The examination of the iron ores was continued, and in addition there was begun an examination of the lead deposits of the southwest. Surveys for county reports were made in Jasper, Cedar, Barton, Vernon, Bates, Howard, Linn, Adair, and Sullivan counties. In 1874, the lead deposits of Cole, Miller, and other central counties were studied, and examinations for county reports were made in Putnam, Schuyler, Chariton, Cole, and Madison counties.

The survey was discontinued after the year 1874, and most of its working material transferred to the State School of Mines at Rolla, the president of which, Dr. Charles P. Williams, was made acting State geologist, with a nominal salary. Little field work was carried on under Doctor Williams, and after the year 1876 no further support appears to have been extended to the work by the State.

Expenses.—The total appropriations for the surveys of 1872–1874 amounted to $60,000 and an additional $19,320 for printing.

Publications.—Up to the time of Mr. Pumpelly's appointment very little had been made public of the results of the surveys, and the changes of management had necessarily retarded and weakened the work. Under Pumpelly's management two reports were issued, both in 1873, one of 323 pages, consisting entirely of county reports, and the other of 655 pages, devoted largely to economic subjects. But one report was issued by the Broadhead survey—this a large octavo of over 700 pages, transmitted in August, 1874. Under Doctor Williams one report—a small octavo of about 200 pages—was issued. The cost of printing these reports is given in the final summation of expenses at the end of this article.

FOURTH SURVEY UNDER ARTHUR WINSLOW, C. R. KEYES, AND OTHERS, 1889–1900.

Organization.—After the suspension of the survey under Professor Williams no public geological work was conducted until the year 1884, when topographic work was begun in the State by the United States Geological Survey. This was continued until July, 1889, up to which time about one-third of the State was mapped on sheets of a scale of 2 miles to the inch and with contour intervals of 50 feet. In addition, W. J. McGee was detailed in 1887 by the national survey to make a brief study of the geology of a portion of Macon County.

The law of May 13, 1889, was evidently framed upon the laws of the preceding survey, though it differed somewhat in detail. The most noticeable differences are the absence of a requirement to collect specimens in triplicate and of a clause requiring county maps and reports to be prepared. The State geologist was, however, directed to complete any detail maps and reports of counties or districts already prepared. The following is a transcript of this law:

An act to provide for a bureau of geology and mines to complete geological and mineralogical survey of the State of Missouri.

Be it enacted by the General Assembly of the State of Missouri, as follows:

SECTION 1. There is hereby created and established a bureau of "geology and mines" for the State of Missouri, which shall be under the direction and in charge of a board of managers, which shall consist of the governor (who shall be *ex officio* president of the board) and four citizens from the State at large, who shall be appointed by the governor, by and with the consent of the senate, and shall hold their office for a term of four years.

SEC. 2. The board of managers are authorized, as soon as they are organized, to appoint one State geologist, who shall be a person of competent, scientific, and practical knowledge of the sciences of geology and mineralogy, and who is not connected with any school or college as an instructor, and who shall be the director of the survey; and said State geologist may appoint such assistants and subordinate assistants and laborers as may be deemed necessary in order to make a thorough and scientific, geological, and mineralogical survey of the State.

SEC. 3. It shall be the duty of the State geologist and his assistants, under the instructions and directions of the board of managers, to carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of the State already begun, with a view to determine the order, succession, arrangement, relative position, dip, or inclination, and comparative magnitude of the several strata or geological formations within this State, and to discover and examine all beds or deposits of mineral contents and fossils, and to determine the various position, formation, and arrangement of the many different ores, clays, rocks, coals, mineral oils, natural gas, mineral and artesian waters, and other mineral substances as may be useful or valuable; also to note carefully the character of the soils and their capacities for agricultural purposes, the growth of timber, and other scientific matters that may be of practical importance and interest; and said geologist shall cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the different geological formations of the State and to mark thereon the localities of the respective beds or deposits of the various mineral substances; and, on the completion of the survey, complete a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

SEC. 4. It shall be the duty of the State geologist to make, or cause to be made, detailed maps and reports of counties or districts as fast as completed, which maps shall embrace all such geological, mineralogical, and scientific details necessary to make complete reports of said districts and counties. The State geologist may also, from time to time, publish or cause to be published any reports of work completed in the form of pamphlets or bulletins for general distribution.

SEC. 5. It shall be the duty of the State geologist to collect full suites of all minerals, ores, fossils, or other mineral substances of scientific or practical interest or utility as may be discovered, and that may be necessary to form a complete cabinet collection, to illustrate the various resources of the State, as may be necessary to assist in preparing the various reports of the survey.

SEC. 6. It shall be the duty of the said assistants to make full and complete examinations, assays, and analyses of all such rocks, ores, soils, or other substances as may be submitted to them by the State geologist for the purpose, and to furnish him with a detailed and complete account of the results so obtained.

SEC. 7. The State geologist, from time to time, may furnish items of general information or new discoveries for publication in newspapers: *Provided*, The preparation of the manuscript and publication thereof does not interfere with the progress or add to the expense of the survey. He may also have authority to furnish cabinets for colleges or public museums, located within the State of Missouri, of minerals, rocks, or fossils: *Provided*, Said institutions shall pay the expense of preparing, labeling, transporting, and putting up said collection; and also, further, that in the selection of said specimens the general State collection is not deprived of duplicates of the same, and that the State collection is not seriously injured.

Sec. 8. The board, with the State geologist, may determine the place for the State cabinet and headquarters of the survey.

Sec. 9. It shall be the duty of the board of managers to report to each general assembly the progress and condition of the survey, an accurate account of money spent, such reports of the State geologist and his assistants as have been completed, together with all such information as may be deemed necessary and useful.

Sec. 10. The board shall have power to take possession of all property of former surveys, whether reports, maps, collections, instructions, or other property belonging to the State, and all persons now in possession of the same shall deliver them up to the order of the president of the board of managers: *Provided*, That no cabinet or library already arranged shall be removed, but the State geologist and his assistants shall have the power at any time to examine or study such collections in preparing their reports.

Sec. 11. The board may make such by-laws and regulations for the government and control of its meetings and labors of the State geologist and his assistants as may be deemed necessary.

Sec. 12. As full compensation for the members of the board of managers they shall be allowed their necessary expenses while attending to the duties assigned them by this act. The board shall fix the salary of the State geologist, not to exceed $3,000 per annum, and his chief assistant, which shall not exceed $1,800; for the principal assistant or paleontologist, if one is employed, not over $1,800.

Sec. 13. The State geologist may, with the approval of the board, appoint other necessary assistants, whose pay shall not exceed $5 per day; such other necessary laborers or assistants as may be necessary, who shall receive a fair compensation for their work. He shall also have power to negotiate for such chemical work, chemical apparatus, and chemicals as may be necessary, and may, from time to time, with the approval of the board, have such work done. He may also, with approval of the board, employ special assistants in paleontology, provided it be deemed necessary.

Sec. 14. All accounts of salaries and expenses shall be made under oath, certified by the board, and filed with the auditor of State.

Sec. 15. The board of managers shall have the general management of the survey, and have full power to remove the State geologist and appoint his successor, when deemed necessary for the good of the work entrusted to him; and the State geologist shall have full control over his assistants and have power to remove them when deemed necessary.

Sec. 16. For the purpose of carrying out the provisions of this act the sum of $20,000 is hereby appropriated, or so much as may be needed thereof.

Sec. 17. The board of managers, the State geologist, and each of his principal assistants shall, before entering upon the discharge of their duties, take the usual oath of office to faithfully perform all the services required of them under this act, and to abstain from all pecuniary speculations for themselves or others in the objects of their survey during its progress.

Sec. 18. The president of the board shall, from time to time, certify to the State auditor the sums of money required to pay the salaries of the State geologist and his assistants and the incidental expenses of the bureau; and on receiving said certificates the auditor of State shall draw his warrant on the treasurer of State for the requisite amount in favor of the parties and persons entitled to receive the same, and shall charge the several sums so paid to the account of the proper appropriation.

SEC. 19. All previous acts and parts of acts inconsistent with this act are hereby repealed.

SEC. 20. The importance of the completion of the geological and mineralogical survey of Missouri at an early day creates an emergency within the intent and meaning of the constitution which requires this act to take effect at once; therefore, this act shall take effect and be in force from and after its passage.

Approved May 13, 1889.

Administration.—Under this law Arthur Winslow was appointed State geologist. He was assisted by Prof. H. A. Wheeler, Frank L. Nason, Paul Schweitzer, G. E. Ladd, Hiram Philips, Erasmus Haworth, J. E. Todd, and Charles R. Keyes. These assistants were appointed by the State geologist with the approval of the board. The salary of the State geologist was fixed as before at $3,000 a year and that of his chief assistants not to exceed $1,800 a year, other necessary assistants receiving amounts not exceeding $5 a day.

Under Winslow's administration the plan of work adopted was (1) to prepare a series of monographic reports upon separate subjects, those of economic importance received first consideration; (2) to prepare successively a series of detailed maps of different portions of the State to be accompanied with special reports containing descriptive details. The subjects undertaken in pursuance of this course were:

1. Lead and zinc deposits; 2, the coal and coal regions; 3, the clays; 4, the iron ores; 5, the mineral waters; 6, the building stones and crystalline rocks; 7, the Quaternary, or, more exactly, the glacial geology; 8, the paleontology; 9, hypsometry; 10, general geological mapping.

The study of lead and zinc deposits was begun in cooperation with the national survey. The work on coals was placed in the hands of Prof. H. A. Wheeler; that of iron ores in those of Frank L. Nason. Paul Schweitzer studied the mineral waters; G. E. Ladd and Hiram Philips, the building stones. Crystalline rocks were studied by Erasmus Haworth, and field work for the preliminary report on the glacial geology was carried on by J. E. Todd. An exhaustive review of the paleontology of the State, by Charles R. Keyes, was also prepared, and many data relating to hypsometry were collected and tabulated.

Winslow continued in the office as State geologist until 1894, when he was succeeded by C. R. Keyes. In 1897 the management (?) of the survey passed into the hands of J. A. Gallaher. E. R. Buckley was appointed State geologist in 1901.

Expenses.—The appropriations for this survey for the two years 1889–90, were $20,000; for 1891–92, $40,000. Out of this sum were paid all salaries and expenses, including cost of publication. The following table shows the total appropriations and expenditures from 1853 down to 1903–1904:

Table showing appropriations for the various geological surveys, with corresponding expenditures; also the size of the editions of the reports issued and cost of the same.

	Appropriated.	Expended.		Appropriated.	Expended.
1853–1862	$105,000	$95,200.00	1893–94	$20,000.00	$19,998.90
1870–71	12,500	2,500.00	1895–96	20,000.00	19,999.89
1872–74	60,000+12,000	72,000.00	1897–98	20,000.00	17,846.43
1876–77	6,500	6,500.00	1899–1900	30,000.00	[1]29,181.60
1889–90	20,000	19,999.60	1901–02	20,052.51	17,039.54
1891–92	40,000	39,999.00	1903–04	20,101.10	20,101.10

[1] This includes a special appropriation of $10,000 for core drilling, of which sum $9,181.60 was expended.

Reports during above period.	Edition (copies).	Cost of publication.
Prof. Swallow's report, 1854	(?)	$5,000.00
Report, 1855–1871	2,000	3,000.00
Pumpelly's report on iron ores and coal fields, 1873	4,000	9,000.00
Report of G. C. Broadhead, 1874	4,000	7,320.00
Report of C. P. Williams, 1877	5,000	1,500.00
Report on Coal Deposits of Missouri, 1891	(?)	6,520.00
Volume 2, Report on Iron Ores of Missouri, 1892	(?)	(?)
Volume 3, Report on Mineral Waters of Missouri, 1892	(?)	(?)
Volumes 4 and 5, Report on the Paleontology of Missouri, 1894, two volumes	2,000	1,597.13
Volumes 6 and 7, Report on Lead and Zinc Ores of Missouri, 1894, two volumes	5,000	2,305.96
Volume 8, Annual Report, 1894	2,000	1,039.94
Volume 9, Report on Areal Geology, 1896	1,500	670.71
Volume 10, Surface Features of Missouri, 1896	1,191	997.48
Volume 11, Clay Deposits, 1896	1,658	1,510.45
Volume 12, Areal Geology, 1898	2,000	1,152.91
Preliminary Report on Structural and Economic Geology of Missouri, 1900	7,000	2,098.33

Museum.—In accordance with the various enactments collections were made by each and all the surveys. Those made by organizations prior to that of 1889 are referred to on page 278. By section 6 of the law of 1889 it became the duty of the survey to collect full suites of all minerals, ores, fossils, or other mineral substances that might be necessary to form a complete cabinet to illustrate the mineral resources of the State. The cabinet thus formed was at first installed in the State capitol building, but later moved to the armory building.

NEBRASKA.

Prior to 1901 no geological surveys of Nebraska had been undertaken under direct appropriations from the legislature, although an attempt was made in 1877 to get a bill through the State legislature to complete the work as left by the United States geologist, F. V. Hayden. It is impossible at this date to learn all the details, but correspondence in the hands of the writer would indicate that jealousy on the part of the Wheeler organization and local personal prejudices had much to do with it. Samuel Aughey, of the State University, would appear to have been actively interested and at one time aspired to the directorship. The bill, however, failed of passage. The regents of the State University, in recognition of the importance of a survey, provided in 1899 the sum of $500 to be expended in the work and $250 for each of the years 1900, 1901, and 1902. In 1901, however, the matter was taken up by the legislature, and Prof. E. H. Barbour, of the State University, appointed State geologist. The work of the survey thus organized passes beyond the time limit of this paper.

NEVADA.

Organization.—No systematic and independent geological survey of the State was ever carried through, although an abortive attempt was made in 1865, the year following the admission of the State to the Union. The following is the text of the act under which the attempt was to be made:

> *The people of the State of Nevada, represented in senate and assembly, do enact as follows:*
>
> SECTION 1. The office of State geologist is hereby created and the board of regents is hereby authorized to appoint a competent person who shall act and be known a (as) "State geologist of Nevada."
>
> SEC. 2. The person appointed as State geologist under the provisions of this act shall, immediately upon his appointment, proceed to make a preliminary and superficial geological survey of the mineral regions of this State, and to collect suitable specimens, and arrange and classify them in a cabinet, to be formed and kept at the capitol of the State, and to prepare a map, marked, and colored in such manner as to indicate the general geological divisions as developed of the country examined. The making of this preliminary or superficial survey shall not occupy more than eight months. At the conclusion of the making of this survey and the report thereon the geologist's cabinet, report, profiles, and map shall be turned over to the State librarian.
>
> SEC. 3. The sum of $6,000 is hereby appropriated, out of any moneys not otherwise appropriated, to be expended toward defraying the expenses which may be incurred under the provisions of this act. The controller of State is hereby authorized and required to draw his warrant on the treasurer in favor of the person whom the board of regents may appoint State geologist, in such sums as the board of regents may truly certify their approval of, the aggregate of the sums drawn for being within the amount hereinbefore specified and appropriated.
>
> Approved March 20, 1865.

So far as can be learned this law was never carried into effect. The year following the matter of a survey came once more before the legislature in a somewhat different form and in connection with the establishment of a State mining school. The following is the text of the act passed at this time, together with its subsequent modifications:

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. There shall be established a mining school, which shall be a nucleus of the State University and a part thereof, as provided in the constitution of this State, and shall be under the control of the board of regents of the same, consisting of the governor, secretary of state, and superintendent of public instruction, and their successors.

SEC. 2. The board of regents shall, within 20 days after the passage of this act, appoint a State mineralogist, who shall be superintendent of said school, and he shall appoint such assistants as may be allowed by the board of regents. He shall hold his office during the term of office of the board by whom he is appointed, and his assistants shall hold their respective offices during the pleasure of the State mineralogist.

SEC. 3. The board of regents shall fix the compensation of the State mineralogist and his assistants, and, subject to the provisions of this act, shall prescribe his duties; but they shall not change his compensation during the term for which he is appointed, unless the office becomes vacant, when said board shall appoint his successor for the unexpired term. The compensation of the State mineralogist shall not exceed $4,000 per annum, and that of his assistants shall not exceed $3,000 per annum each.

SEC. 4. Before entering upon the discharge of their respective offices the State mineralogist and his assistant shall take and subscribe to the constitutional oath of office, and they shall hold their respective offices until their successors are elected or appointed and qualified.

SEC. 5. The board of regents shall provide suitable buildings for said school and for a geological and mineralogical collection, or State museum, in connection therewith, and such furniture, fixtures, and apparatus as may be necessary. They shall, subject to the provisions of this act, make such rules and regulations for the government of said school as may be required, and shall, annually, on or before the 1st day of November of each year, make a report to the governor of the State, who shall cause the same to be published annually, and shall communicate a copy thereof to the legislature at the next ensuing session. Said report shall embrace the report or reports of the State mineralogists, or so much thereof as said board may deem necessary to publish. Said report shall contain a full statement of the condition of said school, financially and otherwise, and such recommendations and other matter as the board may deem proper, and they shall cause the same to be distributed.

SEC. 6. The State mineralogist, subject to the provisions of the act and the rules and regulations adopted by the board, shall have the control and management of said school. He shall at such times and in such manner as he shall determine, visit and examine, with reference to their mineral and other resources, the different portions of the State, and collect such geological, mineralogical, and other specimens, and such information as are of scientific interest or have a practical bearing on the subject of mines or mining or the other natural resources and industrial pursuits of the State.

SEC. 7. All specimens collected by him shall be carefully marked and catalogued at the time he obtains them, and he shall, in connection therewith, as soon as may be, prepare a description of every such specimen and of the locality from which the same was obtained.

SEC. 8. Specimens of all ores, assayed or analyzed at said school, and of all ores presented, shall be kept in said museum, and shall be properly marked and catalogued, in connection with the names of the depositors, and a description of such ores, and such description of the locality from which the same were obtained, as may be procured from reliable sources. With a view of securing uniformity in the classification of rocks, the State mineralogist shall procure and place in said museum characteristic specimens of all the principal rocks, to each of which he shall attach the name and a description thereof, and of the locality from which the same was procured, written, or printed in a legible manner.

SEC. 9. Said specimens, properly catalogued, shall be deposited in the State museum, where they, together with the catalogues, shall be safely kept; and at all reasonable hours they shall be subject to examination by any person who shall conform to the rules and regulations prescribed by the State mineralogist for the government of said school, the museum being regarded as a part of the same.

SEC. 10. In preparing such descriptions and arranging said specimens in the museum careful reference shall be had to the correct illustration of the mineral and other natural resources of this State, and the analogies existing between those of this State and those of other mining sections; and when, at a reasonable cost, it is possible to do so, a statement as to the assay or analyses of said specimens shall be embraced in said description. In addition to the scientific terms used in such descriptions, the terms in common use shall be applied, and in all descriptions and reports the quantities and values, shall be given in the English language and in accordance with the standards adopted by this State.

SEC. 11. He shall, subject to the approval of the board of regents, prescribe the course of studies to be pursued in said school; said course and management of the school shall have special reference to the imparting of the combined scientific and practical knowledge concerning the subject of mines and mining and matters relating thereto.

SEC. 12. He shall annually deliver at least one course of lectures on said subject, at said school, or at such places within the State as the board of regents may direct; and he shall, on or before the 1st day of October of each year, make a report to the board of regents, in which he shall present such facts and recommendations, in regard to mines and mining, and matters relating thereto, and in regard to the character and extent of the natural resources of this State, as in his opinion are calculated to promote the full development of the same.

SEC. 13. In the course of his examinations he may, in his discretion, disseminate information on such subjects, by means of free lectures or otherwise.

SEC. 14. He shall take such compass bearings and barometrical and other observations, and make such notes in regard to the same, and in regard to approximate distances, as will furnish materials for the outlines of a map of the localities over which he shall have traveled in the course of his examinations. He may procure, for the use of said school, maps and diagrams of mines, representing the different classes of mines, and illustrative of their geological, mineralogical, and other leading characteristics, and having particular reference to the position in which the metalliferous deposits have been found; and he shall procure, or cause to be procured, drawings of mining machinery, and of machinery, furnaces, and other works, for the separation of metals from the various ores, and the parting of different metals. He may also procure and arrange in some convenient form, for the use of said school, all information concerning the different modes of working mines and reducing ores, that may be obtained at reasonable cost.

Sec. 15. At the earliest practicable period measures shall be taken to procure, for the use of said school, a library, embracing standard and reliable works on mines and mining, and subjects relating thereto; and all of said maps, diagrams, plans, and information, and said library, shall, at all reasonable hours, and without charge, be subject to the examination of any person who conforms to the rules and regulations concerning the same that may be established by the State mineralogist in accordance with this act.

Sec. 16. Connected with said school there shall be an assaying and analytical department, in which the assaying and analyzing of ores shall be taught; and all ores delivered therein for assay or analysis, shall be assayed or analyzed at a cost to the parties delivering the same, which shall only cover the actual expenses of such work, the charges for the same to be determined by the State mineralogist. At said school a careful and uninterrupted record of meteorological observations shall be kept and forwarded, as nearly as may be, in accordance with the "directions" of the Smithsonian Institution.

Sec. 17. Said school shall be established at such place as the board of regents shall decide upon; *provided*, that at the place so selected the people, or authorities thereof, shall, free of cost to the State, place at the disposal of said board, for the use of said school, such buildings and grounds as may be required for said school; and said authorities are hereby authorized to procure and so furnish such buildings and grounds.

Sec. 18. If the people or authorities of such place, in consideration of the permanent establishment of said school therein, shall convey to said board, for the use of such school, suitable buildings and grounds, and the same shall have been duly accepted as such by said board, said school shall be permanently established at such place; and it shall not be removed therefrom until after said board shall have paid or tendered to the authorities of such place at which said school is located the value of said buildings and grounds, the sum to be determined by a majority of three commissioners, one of whom shall, within a reasonable time, be appointed by said authorities—one by said board, and one by the two thus chosen.

Sec. 19. The State mineralogist shall be allowed, for actual expenses incurred by him while traveling in the service of the State, a sum not exceeding $10 per day while so engaged, and not exceeding in the aggregate $1,000 per annum; such demands, together with the demands for salaries and other expenses of said school, shall, by said board, monthly, be audited, and ordered paid out of the mining school fund or any money in the university fund, subject to such order of the board of regents; and all demands (except salaries fixed by law) shall be subject to the action of the State board of examiners; and, upon the presentation of any such order, duly approved by said examiners, the controller shall draw his warrant on the State treasurer in favor of the party to whom such order was thus given for the amount so allowed, and the State treasurer shall pay the same out of any moneys in said funds subject to such order.

Approved March 9, 1866.

An act to create the office of State mineralogist and define the duties of such officer.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

Section 1. The office of State mineralogist is hereby created.

Sec. 2. A. F. White is hereby appointed State mineralogist. He shall hold said office until his successor shall have been elected and qualified as hereinafter provided.

Sec. 3. At the election in the year 1870, and every four years thereafter, there shall be elected by the qualified electors of the State of Nevada a State mineralogist, who shall qualify and enter upon the discharge of his official duties on the first Monday of January next succeeding his election, and who shall hold said office for four years thereafter, and until his successor shall have been elected and qualified.

Sec. 4. He shall reside and keep his office at the seat of government of this State, except when absent on official duty within the State. He shall be commissioned by the governor, and shall take and subscribe thereon the oath of office prescribed by the law.

Sec. 5. He shall receive as salary the sum of $3,600 per annum, payable quarterly. All the necessary contingent expenses of his office, the expense of an appropriate outfit, and his necessary traveling expenses, shall be allowed by the board of examiners, and audited and paid as are other claims against the State.

Sec. 6. It shall be his duty to visit and examine, with reference to their mineral, agricultural, and other resources, the different portions of the State, and collect such mineralogical, geological, and other valuable specimens, and also such information as is of scientific interest, or which may have a practical bearing upon the subject of mines and mining, agriculture and other resources, and industrial pursuits of the State. He shall visit the several mining districts in each county, ascertaining a record of their history, describe their prevailing geological formation and altitude, the characteristics of the mines, and peculiarities of the ores, products, richness, and development; also he shall ascertain the locality, proper quantity, and character of all the arable grazing and timbered lands belonging to the United States within the bounds of Nevada, and from time to time report the same to the authorities having charge of the public lands belonging to the State, for their information, particularly recommending to them for selection such portions as are valuable, and desirable to be selected by this State in satisfaction of lands granted by the United States to the State of Nevada.

Sec. 7. He shall collect, mark, and catalogue mineralogical and geological specimens, and carefully prepare a description of every such specimen and of locality where each specimen was obtained.

Sec. 8. He shall assay or cause to be assayed, analyzed, and described, so far as practicable and deemed expedient, all specimens of ores, which, together with the statement of the locality from which the same was obtained, shall be printed and attached, or referred to specimen.

Sec. 9. The specimens properly catalogued shall be deposited in a museum, so soon as one shall have been prepared by the State, where they, together with the catalogue, shall be carefully kept, and shall at all reasonable times be subject to examination by any person, subject to the rules prescribed by the State mineralogist.

Sec. 10. He shall have power, and he is hereby authorized to engage the services of one employee, at such times as he may think necessary, fix the wages and time of service of said employee, certify the amount to the board of examiners, who shall audit the same.

Sec. 11. He shall, on or before the second Monday in January, 1871, report to the legislature in detail all acts performed and information obtained under the provisions of this act.

SEC. 12. An act entitled "An act to provide for establishing and maintaining a mining school, and create the office of said mineralogist," approved March 9, 1866, and all acts and parts of acts in conflict herewith are hereby repealed.

SEC. 13. This bill shall take effect from and after its passage.

Approved March 1, 1869.

An act to abolish the office of State mineralogist and provide for the care and preservation of the State museum.

The people of the State of Nevada, represented in senate and assembly, do enact as follows:

SECTION 1. The office of State mineralogist of the State of Nevada is hereby abolished.

SEC. 2. On and after the 1st day of January, A. D. 1879, the superintendent of public instruction shall be *ex officio* curator of the State museum of mineralogical, geological, and other specimens.

SEC. 3. The curator, when visiting the several school districts in this State, in his capacity as superintendent of public instruction, as is required by law, shall make inquiry so far as is practicable into the resources of the mines situated in the respective districts, and inspect the same; collect specimens of ores, ascertain their value, catalogue, and place them in the State museum, and prepare for publication in the appendix of his biennial report as superintendent of public instruction a report as curator of the State museum in detail of his acts performed and information obtained under the provisions of this act.

SEC. 4. The services rendered and expenses incurred by the State superintendent of public instruction as curator of the State museum as aforesaid, he shall be allowed a sum not exceeding $500 per annum, and he shall have further power to engage the services of one or more employees, at such times as he may deem necessary, to clean, rearrange, and catalogue all specimens that are now or that may hereafter be placed in said State museum, who shall be paid a compensation, subject to the approval of the board of State examiners, and on the certificate of the said curator, of a sum not exceeding $500 per annum.

SEC. 5. All claims for services rendered, as is provided in section 4 of this act, shall be allowed by the board of State examiners, and paid by the State treasurer out of any moneys not otherwise appropriated on the warrant of the State controller.

SEC. 6. An act entitled "An act to provide for the establishing and maintaining a mining school, and to create the office of State mineralogist," approved March 9, 1866, is hereby repealed.

SEC. 7. An act entitled "An act to create the office of State mineralogist and define the duties of such officer," approved March 1, 1869, is hereby repealed.

SEC. 8. This act shall not take effect and be in force until on and after the first Monday in January, A. D. 1879.

Approved February 1, 1877.

According to the law of March 9, 1866, an office of State mineralogist was created, which was connected with a proposed State mining school, although it was to be sustained by independent appropriations.

Administration.—Under this act R. H. Stretch was appointed State mineralogist, serving only during the year 1866 and being succeeded the year following by A. F. White, he, in his turn, being succeeded in 1871 by H. R. Whitehill, the latter continuing to serve until the abolition of the office in February, 1879.

The State mineralogist was appointed by the board of regents, who also fixed the rate of compensation; and, although a limit of $4,000 a year was made by the law of 1866 and $3,600 by the act of 1869, the actual amount of salary, as indicated in the reports, appears to have been $2,400.

So far as can be learned, no assistants were regularly employed, although section 3 of the original bill made provision for the same, number not stated, who were to receive salaries not exceeding $3,000 a year each.

It would appear from the report of State Mineralogist Stretch for 1866 that the act creating the office provided for the payment of his salary out of the mining fund, which was expected to accrue from an act passed at a previous session of the legislature, entitled "The location and possession of mining claims," or from the university fund. It appears further that the former act produced no available proceeds and that the university fund was not segregated from the school fund. For these reasons the State mineralogist was compelled to work without any funds whatever to meet current expenses. Nevertheless, on receiving the appointment in the spring of 1866, he proceeded to lay out plans comprising a visit in succession to every mining district in the State, collecting from each a complete series of its minerals and geological formations, and such other information as should be available. During the year he was enabled to secure a collection of some 600 specimens, which it was expected would form a nucleus for further operations. Steps were also taken toward securing a collection to represent the mineral resources of the State at the coming Paris exposition.

Mr. Stretch was apparently succeeded in 1867 by Mr. A. F. White, who seemed to labor under the same financial disadvantages as did his predecessor, and who, in order to accomplish a maximum amount of work with a minimum amount of expense, associated himself with one of the parties under the Clarence King survey then operating in Nevada along the line of the Central Pacific Railroad.

Although an act had been passed providing for the establishment of the mining school, White found no funds at hand from which the board of regents could draw to defray the expenses of the necessary buildings or for organizing and maintaining the contemplated school.

The collections made by Professor Stretch and designed for the international exposition at Paris were taken as far as San Francisco, but not forwarded, as originally intended. They were, therefore, returned to Carson, where it was expected they would form a part of the permanent State museum.

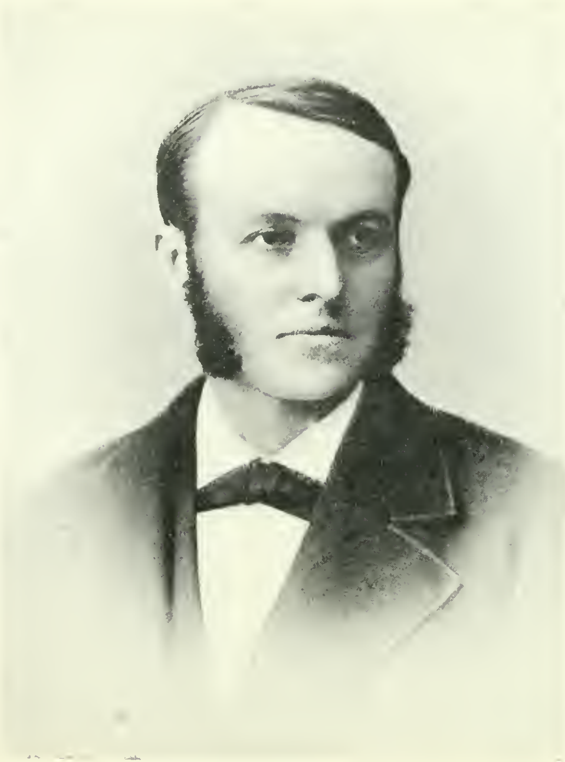
During the seasons of 1869 and 1870 work was continued under the same unsatisfactory conditions as had previously existed, Mr. Calvin Swift serving as an assistant for a period of three months. Some 3,500 miles were traversed during the two years. In 1871 Mr. White was succeeded by Henry R. Whitehill, whose first season's work was largely in the southern portion of the State.

During the seasons of 1873 and 1874 Whitehill spent about seven months in the field, traveling over 4,000 miles and visiting nearly every town and mining district within the State. Necessarily the work was of an exceedingly superficial nature and had to do mainly with the noting of the condition of the mining industry.

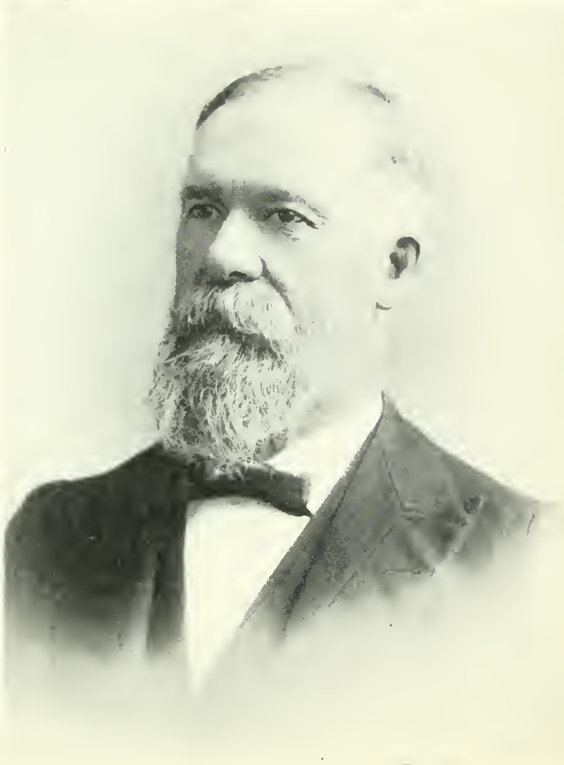
During 1875 considerable time was devoted by the State mineralogist to collecting and arranging an exhibit of the mineral resources of the State for the centennial exhibition in Philadelphia. Some six months of the year were consumed in this work, and in April of the year following Mr. Whitehill proceeded to Philadelphia and remained there three months, classifying and installing the exhibit. The remainder of 1876 was devoted to visiting the mining districts in close proximity to the Central Pacific Railroad, there not being sufficient funds at his disposal to defray the expenses of a more extended trip.

Expenses.—The total expenses of the office of the State mineralogist during the period of its existence, so far as can be gleaned from the annual reports, were as follows:

1866, salary of State mineralogist		$2,400.00
1867–68, salary for two years		4,800.00
1867–68, expenditures, including outfit, traveling expenses, and freight		1,545.24
1869–70, salary for two years		7,200.00
1869–70, expenditures, including outfit, traveling expenses, etc.	$2,734.54	
1869–70, credit by sum realized from sale of outfit	480.00	
		2,254.54
1871–72, salary for two years		7,200.00
1871–72, expenditures, as above		3,991.19
1873–74, salary for two years		7,200.00
1873–74, expenditures, including outfit, traveling expenses, etc.		4,322.46
1875–76, salary for two years		7,200.00
1875–76, expenditures, as above		1,868.25
1877–78, salary for two years		7,200.00
1877–78, expenditures, as above	$1,260.50	
1877–78, credit by sum realized from sale of outfit	500.00	
		760.50
		$57,942.68



George Wesson Hawes



Charles Henry Hitchcock

STATE GEOLOGIST AND ASSISTANT GEOLOGIST OF NEW HAMPSHIRE, 1868-78.

Museum.—In the early reports of the survey reference is made to the preparation of a State museum, and in the report for 1871–72 it is stated that one of the largest and best furnished rooms in the capitol had been allotted for the purpose and five cases suitable for the display of specimens had been prepared. The exhibit at that time contained from 800 to 1,200 specimens. The report for 1873–74 notes the addition of three cases and the preparation of a catalogue of the collections. Beyond this, no printed information is available.

Publications.—The publications under the office of the State mineralogist are limited to seven brief reports, which contain little of other than mining interest. No systematic geological work whatever was accomplished. With the discontinuance of the survey in 1879, under the act of February, 1877, all effort on the part of a survey under State auspices ceased and has never been renewed.

NEW HAMPSHIRE.

FIRST SURVEY UNDER CHARLES T. JACKSON, 1839–1844.

Organization.—In 1839, in response to a popular demand and through the personal efforts of Dr. C. T. Jackson, there was established by the State Legislature of New Hampshire a mineralogical and geological survey of the State. The following is the text of the act:

An act to provide for the geological and mineralogical survey of the State.

SECTION 1. *Be it enacted by the senate and house of representatives in general court convened,* That the governor of this State is hereby authorized and required as soon as may be after the passage of this act to appoint a State geologist, who shall be a person of competent scientific and practical knowledge of the sciences, geology and mineralogy; and the said State geologist shall, by and with the consent of the governor and council, appoint one suitable person to assist him in the discharge of his duties, who shall be a skillful, analytical, and experimental chemist.

SEC. 2. *And be it further enacted,* That it shall be the duty of the State geologist and his said assistant, as soon as may be practicable after their appointment, to commence and carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of this State, with a view to determine the order, succession, arrangement, relative position, dip, or inclination, and comparative magnitude of the several strata or geological formations within this State, and to discover and examine all beds or deposits of ore, coal, clay, marls, and such other mineral substances as may be useful or valuable, and to perform such other duties as may be necessary to make a full and complete geological and mineralogical survey of the State.

SEC. 3. *And be it further enacted,* That it shall be the duty of the said assistant to make full and complete examinations, assays, analyses of all such rocks, ores, soils, or other substances as may be submitted to him by the State geologist for that purpose; and to furnish him with a detailed and complete account of the results so obtained.

SEC. 4. *And be it further enacted*, That it shall be the duty of the said geologist, on or before the 1st day of June in each and every year during the time necessarily occupied by said survey, to make an annual report of the progress of said survey, accompanied with such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same to the secretary of the state, who shall lay such report before the legislature.

SEC. 5. *And be it further enacted*, That it shall be the duty of the said State geologist to cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances discovered, and on the completion of the survey to compile a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

SEC. 6. *And be it further enacted*, That it shall also be the duty of the said State geologist to forward to the secretary of the state from time to time during the progress of said survey such specimens of the rocks, ores, coals, soils, fossils, and other mineral substances, discovered and examined, as may be proper and necessary to form a complete cabinet collection of specimens of geology and mineralogy of the State; and the said secretary shall cause the same to be deposited in proper order in some convenient room in the State capitol, there to be preserved for public inspection.

SEC. 7. *And be it further enacted*, That for the purpose of carrying into effect the provisions of this act. the sum of $2,000 is hereby annually appropriated for the term of three years to be expended under the direction of the governor: *Provided, however*, That the salaries of the said State geologist and his assistant shall not commence until they shall have entered upon the execution of their duties; and upon the completion of said survey and of the duties connected therewith they shall wholly cease and determine.

Approved June 24, 1839.

This law remained in force throughout the existence of the survey, further enactments being made only for the purpose of making additional appropriations and to provide for publication. The survey was not connected with any other institution and was sustained wholly by annual appropriations.

Administration.—Under the act above given Dr. Charles T. Jackson, of Boston, was appointed State geologist, and J. D. Whitney, Moses B. Williams, E. Baker, W. F. Channing, and John Chandler served as volunteer assistants, even to the extent of paying their own expenses. In December of 1840 J. D. Whitney was appointed chemical assistant. These appointments were made by the principal with the consent of the governor and counsel. Neither the salary of the State geologist nor that of the chemist can now be ascertained. The assistants, as noted above, served as volunteers. The officers were not salaried by any other institution.[1]

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[1] It is stated (Life and Letters of J. D. Whitney, p. 40) that this system of volunteers was adopted to avoid political pressure in favor of the appointments of local and none-too-well equipped assistants. A verbal understanding was, however, entered into to the effect that on completion of the term of service the State legislature should be appealed to to make good the deficiency. The plan is said to have worked successfully.

Three suites of specimens are mentioned by Jackson in his first annual report as having been collected and put up in cabinet form, and the suggestion is made that one set should be sent to the Portsmouth Athenaeum and one to Dartmouth College, the remaining portion being sufficient for the use of the legislature. Among these materials was a specimen of the first bar of tin smelted in America, the same having been prepared from tin ores found at Jackson, New Hampshire. This bar was subsequently destroyed by fire, but a second portion is still preserved among the collections of the United States National Museum at Washington.

In the first annual report the method of procedure is outlined somewhat as follows: Knowing the strata to pursue a general northeast course, Jackson proposed to cross them several times at right angles and also to follow along their lines of strike. "These lines of exploration will divide the territory into triangular areas, the boundaries of which will be known, and various excursions across them will make the knowledge of each strike more or less accurate."

Cross sections were described from Portsmouth to Claremont through Concord, from Concord to Wakefield, from Wakefield to Haverhill—all measured by Messrs. Whitney and Williams. Doctor Jackson personally measured another from Concord to Winchester. Messrs. Whitney and Williams also traveled to the northern corner of the State as far as Mount Carmel. The field work closed after a tour to the White Mountains.

The second year's explorations began at Nashua, a party of assistants exploring the southern range of towns between Nashua and the Connecticut River. Doctor Jackson himself explored between Nashua and Portsmouth in the opposite direction. Thence he traveled to Madison, Mount Chocorua, Jackson, Randolph, Lancaster, Shelbourne, back to Lancaster and Dixville Notch. Next he measured a section through Vermont from Lancaster to Lake Champlain. Meanwhile Messrs. Channing and E. E. Hale examined the northern frontier. The remainder of the year's work consisted of explorations in Littleton, Franconia, Landaff, Orford, Lyme, Canaan, Grafton, Amherst, and Keene.

The third report states that towns not previously surveyed were examined as far as possible.

No library was formed.

Expenses.—The total cost of the survey was $9,051.15, the amount being appropriated at the rate of $2,000 annually for the first three years and $3,051.15 for the fourth. This was exclusive of the cost of publication, the figures for which can not be ascertained. A bill for $2,417.35, paid in full of all claims on December 19, 1844, was thought by Prof. C. H. Hitchcock to relate to the illustrations of the final report, though it is possible it may have been used for the relief of the volunteers already mentioned.

Publications.—Three annual reports were rendered, the first two in the form of octavo pamphlets of 164 and 8 pages, respectively, dated 1841 and 1842. The third annual was included in the final report, which formed a quarto volume of 384 pages and 11 plates.

A resolution of the senate and house of representatives, dated December 10, 1840, directed the secretary of state to procure 1,000 printed copies of the first annual report. The second annual was not issued separately from the general legislative document. The additional final report was limited to 600 copies. The reports were distributed with the legislative proceedings, and the final report sent to special institutions and individuals who were named to receive them. The cost of this report is supposed to have been between $3 and $4 a copy.

SECOND SURVEY UNDER CHARLES H. HITCHCOCK, 1868–1878.[1]

In June, 1868, in response to a renewed demand, a second survey was inaugurated. The following is the text of the second law:

An act to provide for the geological and mineralogical survey of the State.

Be it enacted by the senate and house of representatives in general court convened:

SECTION 1. That the governor of the State, by and with the advice of the honorable council, is hereby required and authorized, as soon as may be after the passage of this act, to appoint a State geologist, who shall be a person of competent, scientific, and practical knowledge of the sciences of geology and mineralogy; and said State geologist shall have power to appoint such suitable person or persons as he may deem necessary to aid him in carrying out the purposes of this act.

SEC. 2. It shall be the duty of said State geologist, as soon as may be practicable after his appointment, to commence and carry on, with as much expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of this State, with a view to discover and examine all beds or deposits of ore, coal, clay, marls, and such other mineral substances as may be useful or valuable, and to perform such other duties as may be necessary to complete such survey.

SEC. 3. It shall be the further duty of said State geologist to make a brief annual report of his progress to the secretary of state, who shall submit the same to the legislature, and shall forward from time to time such specimens of mineral substances as may be proper and necessary to form a complete cabinet collection of specimens of the geology and mineralogy of the State, as follows, viz: One complete set to the secretary of state, for preservation at the capitol of the State, which shall be so classified and arranged as to be accessible to all interested in the mineral capacity of the State, and one complete set to the museum of the agricultural college, to be used in the instruction of the young men who may resort there for an agricultural education.

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[1] Mainly from manuscript notes by Prof. C. H. Hitchcock.

SEC. 4. Whenever said survey shall be completed, a report of the same, accompanied by such maps and drawings as may be necessary to elucidate and exemplify the same, shall be published under the direction of said State geologist.

SEC. 5. That, for the purpose of carrying into effect the provisions of this act, the sum of $3,500 is hereby annually appropriated, to be expended under the direction of the governor and council.

SEC. 6. This act shall take effect from its passage.

Approved July 3, 1868.

This law remained in force throughout the existence of the survey. No additional acts were passed, with the exception of one providing for the publication of reports. The survey was not connected with any other institution and was sustained wholly by annual appropriations, and continued uninterruptedly for 10 years.

Administration.—Under the law given above C. H. Hitchcock was appointed principal on September 8, 1868, and continued in office until the expiration of the work May 31, 1878. Various assistants were appointed from time to time. J. H. Huntington was appointed in 1869 and served more or less constantly until 1878, though doing no field work after 1875. Warren Upham was appointed in 1871—at first temporarily—and served until 1878, his special field of study being the glacial drift and surface geology. He also attended to drafting of the maps, plans, and illustrations. Dr. George W. Hawes prepared the part of the final report pertaining to mineralogy and lithology, being employed between two and three years in the work. Other temporary assistants were Prof. George L. Vose, of the Massachusetts Institute of Technology; Prof. Charles A. Seeley, of New York, chemist; and Dr. A. M. Edwards, who studied diatoms. Prof. Thomas Egleston, of Columbia College, commenced work on the optical mineralogy in 1874, but was obliged to give it up because of ill health.

The salary of the State geologist was at the rate of $1,500 a year; that of J. H. Huntington, $500 annually; and that of Warren Upham, about $3 a day. George W. Hawes received $800 a year, this amount being paid from appropriations for publishing the report. The principal was himself connected with Dartmouth College, but the college had no connection whatever with the survey.

The methods of procedure employed by the survey are outlined below. The State being located entirely upon crystalline rocks, the methods employed were not exactly the same as those used in regions of sedimentary deposits. A contour map upon a scale of 2½ miles to the inch was first prepared. The trigonometric stations were obtained through the United States Coast Survey, the boundary survey of 1842, various private surveys, and considerable special work. The roads, villages, streams, and other fixed points were chiefly located from county maps prepared shortly before the survey commenced.

Fitting these to the trigonometric stations obtained as explained, a very accurate map was prepared. The elevations were obtained chiefly by leveling along the railroads. Rarely, use was made of the railroad survey data. The hills were determined by aneroid and mercurial barometers and estimates. Guyot's measurements for the higher mountains were accepted as correct. Leveling from the sea to two stations of the United States Coast Survey enabled certain corrections to be made. Contours on the maps were 100 feet apart, save in the extreme north and south, where they were often given for every 50 feet.

The parallel linear arrangement of the formations allowed the measurement of 13 sections from east to west across the State. Every ledge along these lines was examined and specimens collected of everything important. These were subsequently arranged in the museum, as noted later.

Two fields, each 400 to 500 square miles in extent, were studied with unusual care—one the Ammonoosuc mining field and the other the White Mountains. Every ledge in these districts was visited and special collections made for the museum.

An extraordinary number of observations, it is claimed, were taken of the surface geology, and the survey was the first to give prominent attention to the subject of micropetrology. This work was in the hands of Dr. George W. Hawes.

The several methods employed by the survey, and which were original with it, were as follows:

1. Determining topography by careful surveys of the ridges of land or watersheds and river courses and filling in subsequently the rest of the field by estimate.
2. Methods of studying surface geology.
3. Microscopic methods in lithology.

As already noted, the survey collections were assigned to the New Hampshire College of Agriculture. located in a building belonging to Dartmouth College. This museum consists of (*a*) rocks illustrating sections; (*b*) rocks illustrating ledges between the section lines, about 500 localities being represented; (*c*) special collections, much more minute, as of the White Mountains, Ammonoosuc mining field, Helderberg region near Bernardston, Massachusetts, and a large collection of rocks to illustrate the dispersal of fragments by ice, also a lithological series; (*d*) fossils of Niagara age, full representations of all stones valuable for economic purposes, also a systematic collection of ninety-five mineral species found in the State, with slides for microscope. Duplicate sets of the first section collection were placed in the State Normal School and in the American Museum of Natural History in New York. To the last named were added the continuation of the sections across Vermont and a relief geological map on the scale of 1 mile to the inch.

No library was formed, the publications received being placed in the private library of the State geologist.

Expenses.—All the funds provided by the State were devoted to exploration in the field and the necessary office work; $3,500 were annually appropriated, but the expenditure from year to year varied. The following figures are taken from the official books:

September 8, 1868, to May 31, 1869	$1,150.00
June 1, 1869, to May 31, 1870	3,879.13
June 1, 1870, to May 31, 1871	3,163.15
June 1, 1871, to May 31, 1872	3,296.52
June 1, 1872, to May 31, 1873	3,255.72
June 1, 1873, to May 31, 1874	3,463.03
June 1, 1874, to May 31, 1875	3,500.00
June 1, 1875, to May 31, 1876	3,508.47
June 1, 1876, to May 31, 1877	3,233.25
June 1, 1877, to May 31, 1878	3,750.00
Total	$32,199.27

The cost of the annual reports was intended by the law to have been provided for in the appropriation for the State printer. In several cases the maps engraved were erroneously charged to the expense account of the survey, but this is not the case with the figures given below:

The first annual report cost $219; the second, $482.02; the third, $548.78; the fourth, $210. The final report consisted of three volumes and an atlas. The cost of printing the latter, as paid from year to year, was as follows: 1874, $685.86; 1875, $4,713.40; 1876, $790; 1877, $2,571.05; 1878, $19,638.29; 1879, $5,560.57; making a total for the three volumes and atlas of $33,959.17.

The total cost of the survey, then, was: For expenses, $32,199.27; publication of annuals, $1,459.80; publication of final reports, $33,959.17; for maps and cases, $500. There was also appropriated $200 for the completion of a relief map of the State and $300 for cases in the agricultural college to hold the specimens. The building holding the museum cost $40,000, but contained, in addition to the museum, the chemical laboratories of both colleges and recitation rooms for geology and natural history. For this building the State appropriated $15,000 and Dartmouth College $25,000. In addition, again, a special meteorological observatory was established upon Mount Washington during the winter of 1870–71, costing some $2,000, the amount being obtained by private subscription.

Publications.—Three annual reports in pamphlet form were issued of about 1,500 copies each, and 1,000 copies of the final report. Mr.

E. C. Eastman, of Concord, had 300 additional copies of the final report, with the exception of volume 3, printed at his own expense.

The annual was printed in connection with the usual legislative documents and distributed with them to all applicants. The final report was distributed by vote of the legislature somewhat as follows: One copy each to every town and academy in the State; six copies each to the New Hampshire Historical Society, New England Genealogical Society, Dartmouth College, and the State College; 100 copies to scientific institutions and individuals and others specified, including seven to the Smithsonian Institution. The balance was placed in the hands of the trustees of the State library for sale and exchange.

The provisions for the sale of these documents were somewhat peculiar. A certain number of copies, equal to the number of representatives and senators, were authorized to be sold at $4 each or $16 for the set, to citizens of New Hampshire, who were required to present certificates of residence in the State, signed by the selectman of the town in which they live. No provision was made for sale in any other way by the State. The cost of publication was $33.85 a set.

Benefits.—Among the benefits enumerated are: First, a knowledge of the mineral resources of the State, which had aided in the development of gold, silver, copper, lead, and zinc properties, besides quarries of granite and mica; second, the published accounts relative to the White Mountains were the means of adding several thousand dollars annually to the revenues of individuals; third, the additions to science lay mostly in the classification of the metamorphic and crystalline rocks of northern New England and the establishment of the distinction between the Atlantic and Appalachian systems of elevation carried out through the eastern United States; fourth, studies in lithology; and fifth, discussions leading to the doctrine of the terminal moraine, descriptions of the lenticular hills of drift, later called drumlins, and the discovery of the true origin of the eskers, etc.

From the study of the rocks themselves a triple succession was thought to have been discovered: First, gneiss; second, feldspathic mica schists; third, hydromica and chlorite schists. Purely local names meaning nothing by themselves, they were correlated with the extensions of the terraces into Quebec, Laurentian, and Huronian applied to the first and third, while the middle division was considered of enough importance to have the local name employed—Montalban. All were called Eozoic, in preference to any of the terms of later suggestion for the entire group. It will thus appear that mineral characters were used to distinguish the divisions. The foliated igneous rocks were not separated from the related gneisses. Many quartzites, mica schists, and slates were referred to the Paleozoic column for stratigraphical reasons. Well-defined Silurian fossils determined satisfactorily the age of certain limestones, slates, and sandstones in the Connecticut Valley.

Later interpretations, by Professor Hitchcock included, after 1878, the study of the crystalline schists which attracted considerable attention. Locally the plan of measuring sections in New Hampshire and Vermont in east and west directions was resumed. Dartmouth College came into possession of the collections amassed originally for the State agricultural college and authorized additional work upon them, increasing the number of the sections from 13 to 18, one of which lay chiefly in Quebec and another in Massachusetts. Professor Hitchcock was constantly revising the conclusions of the earlier reports and collecting new specimens of all sorts up to 1908, when his official connection with the college ceased. Complete catalogues of all the sectional and petrographical collections, arranged in accordance with the latest conclusions, were left behind in the cases accompanied by colored profiles and a large relief map. The localities of all the specimens upon the sections are indicated both upon the profiles and accompanying quadrangles.

Some of the later conclusions are the following:

1. The Green Mountain axis is clearly proved to be post-Cambrian. Related to this is a short range of gneiss from Halifax to Reading, Vermont. The Connecticut-Merrimack watershed is underlaid by a well-characterized gneiss, connected in Massachusetts with what some call Algonkians, and passing into Maine north of the White Mountains. Others similar are the Winnipiseogee range running into western Maine, the Manchester range cutting across the southeast part of New Hampshire, and short, parallel ranges in Essex County, Massachusetts.
2. The hydromica-chloritic formations of middle Vermont and the upper Connecticut Valley may be Cambrian or Ordovician.
3. The mica schists, partly calciferous, of eastern Vermont, carry the graptolites of the lower Trenton both in Vermont and Canada, and others are closely related to some of the Montalban areas.
4. The areas of the upper Silurian upon the Connecticut and its tributaries have been enlarged and multiplied, and pass into the Devonian.
5. Patches of the Carboniferous are anticipated.
6. Igneous protrusions occur at several horizons all through the Paleozoic.

NEW JERSEY.

FIRST SURVEY UNDER HENRY D. ROGERS, 1835–1837.

Organization.—As early as 1832, Gov. Peter D. Vroom, in his message to the legislature, advocated the establishment of a geological survey of the State on the ground that it would result in most valuable discoveries in the way of mineral wealth. The legislature, however, took no action. In 1834 the governor returned to the subject again and wrote:

> I am induced to believe that such a survey would lead to the discovery of valuable mineral and metallic resources. A small appropriation will be sufficient to commence with. and I think it due to the State, as well as to the age in which we live, that a commencement be made.

The committee of the assembly, to whom this portion of the message was referred, reported the following bill, which was passed February 26, 1835:

> To provide for a geological and mineralogical survey of the State of New Jersey.
>
> That the governor or person ministering the government of this State be, and he is hereby, empowered to employ some suitable and scientific person or persons to make a geological and mineralogical survey of the State, and make a report thereon to the next session of the legislature, and that he be authorized to draw upon the treasurer for any sum not exceeding in the whole $1,000, in order to defray the expenses of the same.

The legislature of 1836 and 1837 each made appropriations of $2,000 for the continuance of the survey established under this act.

Administration.—Under the act above given, Henry D. Rogers, professor of geology in the University of Pennsylvania, received the appointment to make the proposed survey. He was assisted by no one, so far as shown by the records. Professor Rogers entered at once upon the work which was prosecuted with a systematic plan and enthusiastic earnestness, his first report being submitted to Governor Vroom on February 16, 1836. The plan of work adopted was announced to "lay down upon the map of the State (Gordon's) a series of straight lines, five in number, so drawn as to cross nearly at the same angle all the various formations. The regions adjacent to these lines, embracing a width of several miles on both sides of each, were then selected for more particular and detailed examination; and the extent and boundaries of the several formations, as far as determinable, were delineated upon these portions of the map. The five geological sections or profiles thus surveyed embrace all the strata and afford a general insight into the principal features of the stratification of the State."

The five profiles laid down and studied were: First, a line of country extending across Bergen and Sussex counties, from the vicinity of Fort Lee on the Hudson River, to near Dingmans Ferry on the Delaware; second, a tract extending from the seashore, in Monmouth, to the Water Gap of the Delaware in Warren; third, a tract extending from the bend of the Delaware at Easton, parallel with the general course of the river at Trenton, and thence prolonged to the seashore, south of Barnegat; fourth, a section across Gloucester, reaching from the Delaware River, at Camden, to the seashore near Leeds Point; fifth, a tract traversing Salem, Cumberland, and Cape May counties, from the Delaware to the seacoast.

This plan as carried out has furnished the basis for all the geological investigations which have since been made in the State.

In his report for 1837 the general plan outlined above was adhered to, but investigations were conducted with an eye to more system and greater scientific accuracy. In place of "crossing the strata, as hitherto, in certain lines with a view to determining their more obvious contents and relative situations, they have this year been traced also longitudinally, in order to delineate on the map, with precision, their true boundaries, and to behold throughout their entire area every modification their rocks or mineral deposits might present."

It was noted that considerable chemical work was done and many specimens collected to form a cabinet for the better elucidation of the final report and geological map. No library was formed.

The field work of this survey was practically finished in 1838 and the final report printed in 1840.

Expenses.—The entire cost of the survey, exclusive of publication, would appear to be—1835, $1,000; 1836, $2,000; and 1837, $2,000. No appropriations were asked for after that for 1837.

Publications.—1. Report on the geological survey of the State of New Jersey for 1835 (1836), 174 pages. 2. The same, 1836 (1837). 3. A sketch of what has been achieved toward the geological survey of New Jersey during the past year, 1839. 2 pages. 4. Description of the geology of the State of New Jersey: being a final report, by H. D. Rogers, State geologist. Octavo, 301 pages, with colored map of State on the scale of 6 miles to 1 inch.

SECOND SURVEY UNDER WILLIAM KITCHELL, 1854–1856.

In his annual message to the legislature, dated January 17, 1854, Gov. R. M. Price made the following recommendation:

> It is reported that valuable mineral deposits are frequently discovered by foreigners, and lands purchased from our landholders at nominal prices. A thorough geological survey of the State would doubtless discover mineral deposits to the advantage of our citizens and prevent the speculation now practiced upon them, and increase the value of taxable property beyond the cost of the survey and promote the great interest of agriculture. Fifteen years ago a survey was made which does not meet the progress of scientific discovery. The benefits and practical returns from that survey greatly increased our agricultural productions. The value of marl previous to the survey was unknown, and its use as a fertilizer has greatly enhanced the value of lands.

It is thought other natural fertilizers, veins of phosphate of lime, are known to exist; vast beds of peat and muck, which, if properly composted, would be of great value to our farmers and which a survey would develop, and the State be benefited by the increased wealth of its citizens and value of its lands. I express the hope that a geological survey may be ordered, if a suitable person can be found to perform the service.

In accordance with this recommendation the following act was passed and approved March 2, 1854:

An act to cause a geological survey.

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey*, That the governor of this State be, and is hereby, authorized to employ some competent person or persons to make a geological survey of the State.

2. *And be it enacted*, That the person or persons who may be employed by the governor as aforesaid shall have the right, without molestation or hindrance, to enter upon any lands within this State, not doing any unnecessary damage thereto, with such others as assistants as he or they may deem necessary, to make the required investigations and to effect the objects of said survey.

3. *And be it enacted*, That it shall be the duty of the person or persons so employed as the surveyor or surveyors to make an accurate, thorough, and complete geological survey of the State; which survey shall be made and described in sections of one township each, accompanied by proper maps, diagrams, profiles, and references, with a full scientific and practical description of the rocks, minerals, ores, sands, clays, marls, peat, fossils, soils, and other substances, with a detailed and alphabetical list of the principal localities of rocks, minerals, ores, sands, clays, marls, peat, fossils, soils, and other substances which may be valuable to the people in the several townships of this State.

4. *And be it enacted*, That the governor of this State shall have a general supervision of said survey, the power to employ such person or persons as aforesaid to make said survey, and to discharge and dismiss them as he may think right and proper to further and secure the object of this act; to stipulate and agree with said person or persons so employed, in regard to their compensation, allowance for stationery used, the completion of said survey in manner aforesaid, at the earliest period for the publishing of the work and securing the copyright of the same to the State, and further, to cause a report of the progress of the work to the legislature of this State at the annual meeting thereof, until the same be completed and finished; and the governor of this State for the time being is hereby authorized, by his draft in favor of such person or persons as may be employed as aforesaid, to draw on the treasurer of this State for such sum or sums of money as may be necessary from time to time to pay such persons employed as aforesaid: *Provided*, The several sums so drawn for shall not exceed the whole amount hereinafter appropriated for the survey; and the said treasurer is hereby authorized to pay, out of any moneys not otherwise appropriated, for the purpose and in manner aforesaid, any sum not exceeding $4,000.

5. *And be it enacted*, That it shall be the duty of the governor to require of the surveyor or surveyors aforesaid to collect specimens of the different minerals, rocks, fossils, marls, clays, sands, peats, and of such valuable substances as may be found in the State, to be disposed of in such manner as the legislature may hereafter direct; and also to collect specimens of such substances as may be valuable and peculiar to each county, to be disposed of in such manner as the board of freeholders of the counties where collected shall direct.

6. *And be it enacted,* That when the survey of a county shall be completed in manner aforesaid, it shall be the duty of the governor to require the same to be published and bound in a strong and substantial manner; and as the survey of the State shall progress by counties, published and bound as aforesaid, it shall be the duty of the treasurer to distribute duplicate copies of the same to each of the county clerks, to be by them preserved and kept for the free use and benefit of the people of said counties.

An additional appropriation of $20,000 was made for carrying on the work during 1855, and one of $25,000 for 1856. It was early discovered, however, that State funds were not available to the extent of this last appropriation and the work was curtailed as a consequence. The total amount expended that year was $16,902.69.

Administration.—Under the act of 1854 Dr. William Kitchell was appointed superintendent and State geologist, taking charge of the work in the northern district of the State. Prof. George H. Cook, assistant geologist, was put in charge of the work in the southern district. Dr. Henry Wurtz was appointed chemist and mineralogist, and Gen. Egbert L. Viele was authorized to conduct a topographical survey. The salaries attached to these positions can not at this date be ascertained.

In the northern division work was begun by making detailed surveys, measurements, and other examinations of the iron and zinc mines and of the beds of calcareous marls. In the southern division the geological structure of the greensand marl was studied and its three greater divisions made out and described. Chemical work was begun with an exhaustive examination of the calcareous marls of the northern division. Topographic work was begun in Sussex County, two parties working with plane tables and one by triangulation.

The first report of the survey, issued for the year 1854, comprised 103 octavo pages.

The work of this season was regarded as highly satisfactory and, as noted, a further appropriation of $20,000 was made for carrying on the survey along the lines laid down.

In 1855 active work was prosecuted throughout the entire year, and at its close a report upon the work done was submitted to the governor. This report is an octavo of viii and 248 pages, with an outline map of the State on a scale $\frac{1}{400000}$, on which the triangulation projected for the northern portion of the State was laid down; a large map and profile of the Hibernia iron mine, and numerous illustrations of scenery, of geological formations, and of mines and mining machinery.

In the topographical department General Viele reported that the triangulation had been begun at 25 stations, and 460 observations had been made. Plane-table parties were put in each of the counties of Sussex, Morris, Salem, Monmouth, Hudson, Warren, Cape May, Cumberland, and Atlantic. The surveys of Sussex and Cape May were completed and the maps drawn, and good progress had been made in several other of the counties.

In the southern division geological work was continued in tracing out and describing the subdivisions of the greensand marl beds and the Cumberland marls, in studying the geological structure of the beds of fire and potters' clay, and the geology of the formations on the seashore and on Delaware Bay, with the evidences of recent change and subsidence. Chemical examinations of the marls, clays, and other substances were given. with much matter relating to the agriculture of the country.

In the northern division a detailed statement of the physical geography of the country was given, with its mountains, valleys, lakes, rivers. and then a summary of its geology, its rocks, minerals, and ores. Numerous local details of mines were also given, and with it the work of Doctor Wurtz is included, where the latter describes minutely the composition of the rocks in the mine walls and the ores themselves.

This report was received with much interest, and was printed and widely circulated. The appropriation of $25,000 was made at the beginning of the year for the work of 1856, and for the expenses of engraving the maps of Sussex and Cape May, and printing 1,000 copies of the report and map of Sussex, and 500 copies of the report and map of Cape May. Provision was also made for the distribution of copies to various bodies of persons, amounting to 200 or more, and the rest were to be sold at $3 a copy for that of Sussex and $2 for that of Cape May.

As previously noted, however, the State funds were not available for the sum appropriated, and the work was greatly diminished in its extent and some portions entirely suspended. The limited amount of work which was done was by those in the service who were willing to go on at their own charge and trust to the succeeding legislature to provide the means for reimbursing them.

The report for the year 1856 was made to Governor Price at the close of his term of office.

This report was printed as an octavo of 79 pages, and contains an account of the work done in the geology of the northern and southern divisions of the State, and in its topographical survey. It was also accompanied by a catalogue of plants of Monmouth and Ocean Counties, by Dr. P. D. Knieskern, of Shark River.

Doctor Kitchell reported that detailed surveys of the geology, scientific and economic, were about completed for the counties of Sussex and Morris and were considerably advanced in Essex and Hudson counties. He wrote out a fuller account than had been given before of the magnetic iron ores and their occurrences and distribution in the rocks, and in the use of the magnetic needle in searching for new beds of that mineral; he also wrote upon the methods and economy of working the ores.

In the southern division the assistant in charge reported that the geology of the county of Cape May was completed and the report and map published. The county of Monmouth had been nearly all surveyed, and a considerable portion of Cumberland, and much of the chemical work connected with the analyses of soils, marls, and other fertilizers was done. The report also contained a full statement of the agriculture of that portion of the State, the opportunities offered for its further development, and the natural advantages furnished for its profitable pursuit.

It was the plan of the survey to publish its results in county reports, each of which was to be accompanied by a topographic map of the county. The county of Cape May, in the southern division, was the only one that was completed and published. It is a large octavo of 208 pages, and contains a folded map of the county on a scale of $\frac{1}{50000}$. It also contains numerous illustrative views and sections. The geology is very simple, only the Quaternary to be found in the county, and the surface so uniformly level that there is not an elevation 40 feet above the sea in it. Its sandy and gravelly loams, its salt marshes, and its sand beaches are described, and the wear of its shores, and the changes of level, for which it furnished remarkable proofs, are treated at length. Its climate and its agricultural resources are given, and lists of animals, birds, fishes, flowering plants, and algae are also published; a sketch of the early history of the county of Cape May, by Maurice Beesley, is also included.

General Viele reported for the topographical department that work on a diminished scale had been vigorously prosecuted, though under discouraging circumstances, during the year, and that the following was a summary of the work thus far accomplished:

County of Cape May: Survey completed; map drawn, engraved and published.

County of Sussex: Survey completed; map drawn and partly engraved.

County of Monmouth: Survey completed and map drawn.

County of Morris: Survey nearly completed and map partly drawn (could have been completed in about three weeks).

County of Warren: More than half surveyed.

County of Salem: Half surveyed.

County of Cumberland: Half surveyed.

County of Hudson: This county could have been completed in four weeks, with the aid (which had been offered) of the New York Harbor commissioners' work.

The legislature failing to make appropriations, the work of the survey was brought to a close at the end of 1856. As noted in article 5 of the act establishing the survey, the surveyors were required to collect specimens of the different minerals, fossils, etc., subject to the disposal of the legislature, but no museum seems to have been established, and apparently no library.

Expense.—As already noted, the total expenditures of this survey amounted to $36,902.69.

In 1860, through the interposition of the State agricultural society, Doctor Kitchell was allowed the free use of the materials collected by the surveys just mentioned, and authorized to complete and publish results of the three years' work in one volume, with map, on a scale of not less that 3 miles to 1 inch, the same to be done without expense to the State. Under this authority Doctor Kitchell, working in connection with G. M. Hopkins, a civil engineer, prepared and published a good geographical map on a scale of 2½ miles to the inch. The death of Doctor Kitchell, which took place in 1861, before he had written out any full account of the geology of the State, put a stop to the proposed volume on geology.

THIRD SURVEY UNDER GEORGE H. COOK AND J. C. SMOCK, 1864–1900.

In 1863 the State agricultural society again interested itself in survey matters and obtained the passage of an act authorizing its officers to receive the State property which had been in the possession of Doctor Kitchell and transfer it to Prof. George H. Cook or some other suitable person, in order to complete the survey as proposed in the original agreement of Doctor Kitchell. During the season of 1863 a section across the State, from the Atlantic shore at Shark River Inlet to the Delaware Water Gap, was carefully studied and drawn and a short report prepared by Professor Cook on the State surveys as made by Professor Rogers and Doctor Kitchell and the benefits derived from them. This report he was invited to read before the senate and the assembly in their regular sessions. In it was said:

> The importance of having the geological survey so executed and published that all of our citizens may understand the geology of the State can hardly be overestimated. To the practical man it is of the first importance to know that the materials of the globe are not jumbled together in a confused mass, where any particular substance can only be found by chance, but that there is an orderly arrangement of them, and each is to be found in its appropriate place. The soils upon each rock formation have their peculiar characteristics, and the farmer who wishes to devote himself to dairying, to the raising of

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stock, of grass, of grain, of fruits, or of garden vegetables will look for the rock formation and soil upon which his special product is most profitably raised.

Our iron need only be looked for in one kind of rock, and that rock is confined to a particular district of country. The limestones are all in regular layers, traversing the country in a northeast and southwest direction, and never in any other. Our greensand marls are only found in one favored portion of the State. The fire clays are only in one belt of country which crosses the middle of the State from northeast to southwest. It would be worse than useless to look for magnetic iron in southern New Jersey, marl in the northern part of the State, or coal beds anywhere within our bounds. It is only by surveys of this kind, carefully carried out over the whole country, faithfully described and illustrated, and the results brought within the reach of all our citizens, that we can fully and profitably make this arrangement known and appreciated. Our abundant but undeveloped resources require from the State this kind of survey and publication.

Following the reading of this report the bill for the completion of the geological survey was prepared, passed by both houses, and signed by the governor, the Hon. Joel Parker. It is as follows:

An act to complete the geological survey of the State.

Whereas, the senate and general assembly of the State, by an act passed March 2, 1854, authorized a geological survey of the State to be made, which survey was subsequently suspended by the State; and

Whereas, the State agricultural society, under the authority granted to it by the act of February 25, 1863, has shown a laudable zeal in continuing the said survey; and

Whereas, it appears by the report of Robert C. Bacot and Jacob Herbert (committee of the legislature), made March 11, 1857, that of the former appropriations made by the State there was, at that date, an unexpended balance amounting to $8,897.31, which balance still remains to the credit of that account; and

Whereas, it is the duty of the State to develop and render available to the fullest extent the facts relative to its great natural resources, as also of its agricultural, mining, mechanical, and other industrial interests: Therefore—

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey*, That the duty of completing the said survey be, and is hereby, resumed by the State, said survey to be completed within a period not to exceed four years, and at an expense not to exceed the sum of $20,000, aside from the cost of publication, and all laws conferring on the State agricultural society authority to continue the survey, or transferring to it the State property used by the survey, be, and the same are hereby, repealed.

2. *And be it enacted*, That the sum of $20,000, of which the unexpended balance of former appropriations shall be part, be and is hereby appropriated to carry out the provisions of this act.

3. *And be it enacted*, That the appointment of George H. Cook by the State agricultural society is approved of, and that the said George H. Cook is hereby appointed State geologist, with authority to receive from the State agricultural society the State property used by the survey, and employ, control, and use the same; to employ such assistant or assistants as shall seem to him necessary for the proper prosecution of the survey; and it shall be lawful for the said George H. Cook and the person or persons employed by him to enter, without

molestation, upon any lands in this State which he or they may deem necessary to further the object of the said survey; and it shall be the duty of the State geologist, on or before the first day of January of each year, to furnish to the president of the board of managers (hereinafter to be created) a detailed statement of his expenditures, with the vouchers thereof, and also a report of his operations for the preceding year.

4. *And be it enacted*, That to promote the objects which this act has in view there shall be a board of managers of the same, to consist of 11 members, one of whom shall be the governor of the State, who also shall be president of the board, and two members from each of the five congressional districts of the State; and the State geologist shall make his annual report to the president, who shall appoint from the members of the board a committee to examine the annual accounts of expenditure, and the president shall submit the same and all matters pertaining to the survey at the first following session of the legislature; and it shall be lawful for the president and board of managers, or a majority of them, to make yearly agreements with the State geologist as to his own and the salaries of his assistant or assistants, but such temporary assistance as may be needed, the purchase of the necessary implements and materials, the means necessary for transportation and all other incidental expenses shall be under the control of the State geologist; and it shall be the duty of the members of the board, in addition to those already specified, to furnish from time to time to the State geologist any and all information which will contribute to the more full and complete development of the facts relating to the agricultural, mining, mechanical and other industrial interests of the State.

5. *And be it enacted*, That the governor of the State is hereby authorized, by his draft in favor of the State geologist, to draw on the treasurer of the State for such sum or sums of money as may be called for by the State geologist: *Provided*, The several sums so called for shall not in any one year exceed the one-fourth part of the appropriation made in section 2 of this act, to wit: $20,000.

6. *And be it enacted*, That it shall be lawful for the State geologist to take from the first yearly installment a sum not to exceed $500 to reimburse himself for the expenses incurred in prosecuting the survey of the past year.

7. *And be it enacted*, That the board created by this act shall be a committee of publication, with authority to print and publish the annual and final reports of the State geologist, and also to direct the distribution of suites of the geological, mineralogical, and other specimens collected in the survey, to such literary, scientific, and other institutions as will best conduce to the interests of the citizens of the State.

8. *And be it enacted*, That the following-named persons are hereby appointed and shall constitute the board of managers of the geological survey of the State, viz: President, Joel Parker; managers, David Potter, of Cumberland, Andrew K. Hay, of Camden, in the first district; William Parry, of Burlington, John A. Roebling, of Mercer, in the second district; Isaac R. Cornell, of Somerset, Henry Aitkin, of Union, in the third district; Abram S. Hewitt, of Passaic, Andrew B. Cobb, of Morris, in the fourth district; William W. Force, of Essex, J. R. Wortendyke, of Hudson, in the fifth district; and power is hereby given to the said board, or a majority of them, to fill any vacancies which may occur.

9. *And be it enacted*, That this shall take effect immediately.

Approved March 30, 1864.

This act was afterwards amended and supplemented as follows:

15. SEC. 1. That so much of the act to which this is a supplement as directs and requires the geological survey of the State to be completed within a period not to exceed four years, be, and the same is hereby, repealed.

Approved March 29, 1868.

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey,* That for the purpose of completing said survey, the annual appropriation of $5,000 be and is hereby continued for a further period of four years, subject to be suspended at the discretion of the governor; and the treasurer of this State, upon the warrant of the comptroller, shall be, and is hereby, authorized to pay such bills of expenses as may be audited and approved by the board of managers in favor of the State geologist.

2. *And be it enacted,* That this shall take effect immediately.

Approved April 1, 1869.

A supplement to the act entitled "An act to complete the geological survey of this State," approved March 30, 1864:

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey,* That for the purpose of completing said survey the annual appropriation of $5,000 be and the same is hereby continued for a further period of four years; and the treasurer of this State upon the warrant of the comptroller shall be, and is hereby, authorized to pay such bills as may be audited and approved by the board of managers in favor of the State geologist.

2. *And be it enacted,* That this act shall take effect immediately.

Approved March 11, 1873.

16. SEC. 1. That the board of managers authorized by section 4 of said act are hereby authorized to increase the number of their members from 11 to 15, one of whom shall be the governor of the State, who shall be president of the board, and two members from each of the seven congressional districts of the State; and the powers and duties of the board thus constituted shall be the same as defined in the act to which this is a supplement.

Approved April 9, 1875.

17. SEC. 1. That for the purpose of completing said survey, an annual appriation of $8,000 be, and is hereby, made and continued for the period of five years; and that the treasurer of this State, upon the warrant of the comptroller be and is hereby authorized to pay such bills as may be audited and approved by the board of managers in favor of the State geologist.[1]

Approved March 30, 1876.

A supplement to the act entitled "An act to complete the geological survey of the State," approved March 30, 1864.

1. That the annual appropriation of $8,000 per annum for the completion of the geological survey of the State, made in the supplement of this act, which was approved February 18, 1880, be further continued for five years.

Approved May 2, 1885.

20. SEC. 1. That section 7 of said act (see sec. 14, ante) be amended so as to read as follows:

That the board created by this act shall be a committee of publication with authority to print and publish the annual reports of the State geologist; and also to direct the distribution of suites of the geological, mineralogical, and other specimens collected in this survey, to such literary, scientific, and other institutions as will best conduce to the interests of the citizens of the State; and should the general demand for its publications require, the said board is hereby authorized to furnish said publications at the cost of paper, printing, and distribution, or to authorize agents duly appointed to make sales on like terms; and any money which may be received for making sale shall be paid into the Treasury of the State.

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[1] Section 2 of this act repealed a "Supplement to said act approved March 11, 1873."

Approved March 7, 1888.

Under the act of 1864 work in the survey was resumed with the purpose of collecting together all that could be found relating to the geology and natural resources of the State in the four years allotted to the work, and to prepare and put these in such form as might be most useful and acceptable to the people. Short pamphlet reports of the conditions and progress of the survey were made every year to the governor. That of 1864 contains 24 pages, with a colored geological map and a profile of the rocks of the State, each in an octavo page. The report of 1865 contains only 12 pages; the one of 1866 has 27 pages; and that of 1867 has 28 pages. The matter in these, however, is all reproduced in the Geology of New Jersey, which was printed in 1868, and is the only report of that year.

The organization of the survey for those years was as follows: George H. Cook, State geologist; John C. Smock, assistant geologist. Maj. T. B. Brooks was engaged in topographic and magnetic surveys of iron mines and iron-ore lands in 1864; Dr. David Murray was engaged in preparing projection for a new map of the State, and in collating and revising in the field the materials for such a map in 1864–65; Dr. Charles C. Abbott voluntarily devoted himself to the preparation of catalogues of the vertebrate animals of the State during the years 1864–1867; and G. M. Hopkins, civil engineer, compiled the maps for the use of the survey and for publication, using such material as was available from former surveys and from old maps. He also surveyed and drew a topographic map of about 80 square miles of the district of Morris County in which the largest iron mines are located. His work was done in 1865–1867. Edwin H. Bogardus was employed as chemist through the years 1866–67; Francis C. Van Dyck was engaged in chemical researches during part of the years 1866–67; Paul Cook was occupied in tracing lines of magnetic attraction and beds of iron ore in 1866–67; lines of magnetic attraction were also traced by John Hance and others.

The work of the four years was completed as proposed, and at an expense within the appropriation made for it. The report, however, was not ready for publication, and the section requiring its completion in four years was repealed March 24, 1868.

The report, which was issued the latter part of 1868, was entitled The Geology of New Jersey. It is an octavo of xiv and 899 pages and is illustrated by numerous explanatory sections and sketches and is accompanied by a portfolio of eight maps. In this report was brought together the work of all those who had been engaged, with recognition of their services; the geographical material which could be made available; the systematic geology of the State as given in four divisions—namely, the Azoic and Paleozoic, Triassic, Cretaceous, Tertiary and recent formations; historic geology; economic geology; and an appendix including lists of Invertebrate Fossils, by T. A. Conrad; of Extinct Mammalia and Reptilia, by E. D. Cope; of Minerals, by Rev. E. Seymour; of Vertebrate Animals, by Dr. C. C. Abbott; and of Elevations in New Jersey, from various sources.

The four general maps were on a scale of 2 miles to an inch and covered the whole State, following the four divisions mentioned above. The map of a group of iron mines in Morris County was drawn to a scale of 3 inches to a mile. Those of the zinc mines of Sussex County, of the Oxford and Ringwood iron mines on a scale of 8 inches to 1 mile.

By the act of April 1, 1869, the survey was continued for another four years, an annual appropriation of $5,000 being provided for. Professor Cook was again appointed geologist and continued to act in this capacity and under the several supplemental acts until his death in 1889. He was assisted during these years as follows: 1869, 1870, E. H. Bogardus (chemist), E. A. Bowser (engineer); 1871, 1872, John C. Smock (assistant geologist), E. H. Bogardus, E. A. Bowser, George Howell; 1874, the same, with J. K. Barton, assistant to Bowser; 1875, the same, with Ed. Reiley and R. A. Meeker, collectors.

In the spring of 1875 Professor Bowser was appointed assistant in the Coast Survey Service, with the duty of conducting triangulation survey over New Jersey. He continued this work until 1885.

The legislature of 1876 passed an act continuing the survey five years longer, with annual appropriations of $8,000. Doctor Cook served, as already noted, with the assistance of the same corps as in 1875, including also W. C. Whitehead and George McC. Taylor, surveyors. The personnel of the survey remained the same until 1880, when C. C. Vermeule was added as a topographic assistant. Profs. J. S. Newberry and R. P. Whitfield undertook the description of the fossil plants, fishes, and invertebrates, and N. L. Britton the preparation of a list of the wild plants of the State. The assistants from 1880 to 1884 were the same but that Mr. Bogardus closed his work in April, 1881.

In 1885 the personnel was limited to Doctor Cook and C. C. Vermeule. In 1886 it was increased by the addition of N. L. Britton and F. J. H. Merrill, who continued to serve during 1887. In 1888 the force remained the same, with the exception of F. L. Nason, who replaced F. J. H. Merrill. In 1889 Irwin S. Upson was added to the force. With the death of Doctor Cook, Upson was appointed assistant in charge of office and served until the appointment, on October 1, 1890, of J. C. Smock as State geologist.

Collections.—The act of 1854 and those of the ensuing years provided for the collection of specimens of rocks and minerals to be disposed of as the legislature might direct. Under these conditions an excellent collection of the minerals, fossils, building stones, rocks, woods, and everything to represent the natural products of the State was placed in a museum in the statehouse at Trenton. The burning of the statehouse during the winter of 1885 resulted in the destruction of all but that portion which had fortunately been sent to the exposition at New Orleans. Suites of specimens representing the rocks of the State were also sent to the various colleges.

Publications.—By section 7 of the act of 1864, and again by the supplemental act of 1888, the board of managers was constituted a board of publication, the supplement of 1888 giving authority, should the general demand require, to sell the publications at cost of printing and distribution, or to authorize agents, duly appointed, to make sales on like terms, any money thus received to be paid into the treasury of the State. The legislature in assuming the publication had also the right of free distribution, which was liberally exercised. Hence few, if any, copies were sold.

The editions of the annual reports have varied from 3,000 to 8,000 each, and the final reports and maps in editions of from 1,000 to 2,000 copies each.

Doctor Cook died on September 22, 1889. The legislature in the spring following passed supplemental acts, which were still further supplemented in the spring of 1894. The text of these various enactments is given below:

A supplement to an act entitled "An act to complete the geological survey of this State," approved March 30, 1864.

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey*, That the annual appropriation of $8,000 per annum for the completion of the geological survey of this State, made in the supplement to this act, which was approved May 2, 1885, be further continued for five years.

2. *And be it enacted*, That whereas the office of State geologist, formerly held by George H. Cook under this act, is now vacant, said office shall henceforth, from time to time, be filled by the appointment thereto of a competent person by the board of managers of the geological survey, who shall hold office

during the pleasure of the board, such appointment to be subject to the approval of the governor; and the person so appointed State geologist, and his assistants, shall have the same authority and perform the same duties as if he had been named and appointed in this act, subject at all times to the direction of the board.

3. *And be it enacted*, That this act shall take effect immediately.

Approved May 12, 1890.

An act to provide for the establishment of a museum of the geological survey of the State.

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey*, That a museum for the reception and exhibition of collections of the natural products and minerals of the State, and of classified collections of specimens illustrating the structural and economic geology, physical geology, and natural history of the State, be, and hereby is, established.

2. *And be it enacted*, That the direction and management of said museum shall be committed to the board of managers of the geological survey, who shall appoint a curator therefor.

3. *And be it enacted*, That the officers in charge of the statehouse are hereby authorized and directed to provide a suitable room or rooms therein for the permanent location of said museum, and, in connection therewith, suitable and convenient office room for the geological survey of the State, such rooms to be furnished and provided with all necessary appliances.

4. *And be it enacted*, That the museum hereby established shall be known as the museum of the geological survey.

Approved, May 23, 1890.

A further supplement to an act entitled "An act to complete the geological survey of the State," approved March 30, 1864.

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey*, That the State geologist, under the direction of the board of managers of the geological survey and with the assistance of a competent botanist to be selected by said board for his expert knowledge of forestry and of the forest trees of this State, and such other expert assistance as may be required for the purpose, shall make an investigation to ascertain the extent, character, and location of the wild lands in this State which are suited for permanent occupation by forests rather than by agriculture, and shall report the results of such investigation to the legislature, together with a statement of what part or parts of such lands would be suitable for a State forest reserve, and the advantages as regards the timber supply, water supply, scenery, and climate of the State, which would accrue from the conservation of existing forests by the establishment of such reserve or otherwise. The investigation so to be made shall determine the extent to which forests of timber of commercial value now exists in the State, and include a study of the localities and areas which are especially adapted to the growth of designated kinds of timber of commercial value. It shall also include an examination as to the presence or absence of forest cover upon the slopes and summits of more important watersheds of the State, and a study of the effect of such conditions as now exist upon the maintenance of the streams therein and the regulation of the freshet flow thereof. The report to the legislature shall state the arguments touching the beneficial effect upon climate and rainfall attributable to the presence of forests, and shall likewise present an outline of the policy and legislation of other States and

countries for the preservation of the forests and their regulation for public ends, so far as the same may be applicable to this State.

2. *And be it enacted*, That the expense of making such investigation and report, shall, when duly audited by the board of managers and approved by the governor and comptroller, be paid out of any funds in the treasury not otherwise appropriated, and shall be limited to $5,000.

3. *And be it enacted*, That this act shall take effect immediately.

Approved May 1, 1894.

A further supplement to an act entitled "An act to complete the geological survey of the State," approved March 30, 1864.

1. *Be it enacted by the Senate and General Assembly of the State of New Jersey*, That the board of managers created by section 4 of said act are hereby authorized to increase the numbers of their members so that there shall be two members representing each congressional district as at present constituted, or as they may be hereafter established. besides the governor of the State, who shall be president of the board: *Provided*, That all members of the board now in office shall remain in office the same as if appointed under the present act, and shall represent the districts from which they were respectively appointed, and the board thus constituted shall have and exercise all the powers heretofore conferred by law upon the board of managers.

2. *And be it enacted*, That the further supplement to said act which was approved March 23, 1892, and which is known as chapter 118 of the laws of the year 1892, be, and the same is hereby, repealed, and that this act shall take effect immediately.

Approved April 24, 1894.

Administration.—Under the act of May 12, Prof. John C. Smock was appointed State geologist, in which capacity he continued to serve until July 1, 1901. The assistants during 1890 were F. L. Nason and I. S. Upson. as before, and C. W. Coman. In 1891 and 1892 the force of assistants consisted of Messrs. Upson, Vermeule, and Coman, with the addition of Prof. R. D. Salisbury. During 1893 and 1894 the number was reduced to Upson and Salisbury, though the latter was assisted by H. B. Kümmel, Charles E. Peet, and G. N. Knapp. A. H. Chester served as chemist to the survey. In 1895 Lewis Woolman took charge of investigations relative to artesian wells. The force thus constituted served until 1898, when Gifford Pinchot was added as forester. In 1889 Mr. Kümmel, hitherto Professor Salisbury's assistant, was appointed on the survey staff, and Mr. Stuart Weller was placed in charge of the paleozoic investigations. Professor Smock continued as State geologist until July 1, 1901, when he resigned and was succeeded by Henry B. Kümmel.

Results.—The results of the various surveys as detailed in the final and special reports, are as follows:

The work of the early surveys was chiefly economic and the attention and effort were concentrated on the preparation of a report upon the geology and a geological map of the State. These were published in 1868. This report was in great demand, as it gave the first elaborate account of the mineral resources and geology of the State. The geological map was based upon the county atlases and was perhaps as accurate as could be expected under the circumstances.

Even at the time of publication of this report it was recognized by Doctor Cook that, through lack of time and means, many important problems had been neglected altogether or only briefly touched upon. A series of annual reports was, therefore, planned, which should successfully deal with important topics. These reports have been published each year since 1869, each volume, as a rule, treating of several topics rather than a single one.

Since 1868 the work has been divided into three groups--economic, topographic, and scientific. No hard and fast lines have, however, been drawn between the groups, and many of the problems investigated belong equally well in either one or even in all three.

The topographic work, in the preparation of accurate maps, has been of great economic value, and much which, on its face, was of a purely scientific nature, has led to results of great practical value on the economic side. For convenience, however, there was grouped under economic work only those investigations which bore most directly upon the wealth of the State. The topographic work included the surveys and publication of geological maps, while under scientific work was placed those investigations which had chiefly an educational aspect, either in increasing human knowledge or in giving wider currency to facts of geologic and geographic interest.

Economic work.—The nature and extent of the iron ores of the State received much attention from Doctor Cook. Magnetic surveys were made in numerous instances and at frequent intervals; all the active mines were visited, samples of the ore collected, and numerous analyses made. The reports for 1873, 1874, 1879, 1883, 1890, and 1896 contain the most important papers on this subject. Since 1896 brief annual reports only have been made to cover the operations of the active mines.

Clay deposits received early attention. Considerable data was published in the report of 1868, and 10 years later Doctor Cook wrote a special report on the Woodbridge and Amboy clays, which was the first elaborate report on this subject by any survey and was for years regarded as standard. The greensand marls of the southern portion of the State, being in the early days of the survey in great demand for fertilizers, the first geological map was made to include the location of all the marl belts, and in the reports of 1868, 1873, and 1886 the deposits are described and numerous analyses given, as well as instructions for their use. In the report for 1892 there was an interesting paper concerning the origin of the beds. Between 1875 and

1880 many analyses of soils were made and results of value to agriculturists were obtained. These were made public in the annual reports for 1878–1880.

The wide extent of sand for glass making in southern New Jersey was pointed out in the volume for 1868, and in the annual for 1878 all the known beds were located and described. Several reports contained brief papers upon the building stones of the State, but an exhaustive study remains yet to be made. The geological map of the State showed the distribution of the trap sheet which affords the best material for road metal and concrete, and the report of 1898 contained a list of all the trap-rock quarries then in operation. In the report for 1896 was shown the distribution of all the available road gravel in Camden, Gloucester, Cumberland, and parts of Salem, Burlington, and Monmouth counties.

The first permanent Portland cement plant in the State was established near Phillipsburg, partly as a result of the information furnished by the survey. Later, as a result of an investigation of the fossil faunas of the rocks of Warren and Sussex counties, it was found that the cement beds could be traced readily by their fossils, and a report upon the manufacture of Portland cement and the occurrence of cement rock was published in the annual for 1900.

The drainage and reclamation, for purposes of agriculture, of the large areas of swamp land along the Pequest, Wallkill, and Passaic Rivers was early advocated by Doctor Cook. Surveys of all these areas were made, and between 1873 and 1875 the drainage along the Pequest, recommended by the survey, was carried through by a commission appointed by the supreme court for that purpose. In 1896–97 plans and estimates for the reclamation of the Hackensack meadows were prepared.

The water power and water supply of the State were early recognized as an important subject for the survey and were included in its field of investigation. The quality of the surface waters was tested by numerous chemical analyses, and the quantity of potable waters on the various watersheds was determined by a long series of stream gaugings to determine the amount of stream flow, and by studies of rainfall records to determine the amount of precipitation and evaporation. These studies were made public in a special report upon the water supply in 1894. Since that time the subject of great floods has also been specially investigated.

In 1894 the survey was charged by the legislature with the investigation of the forestry resources of the State. Reports on this subject were made in 1895, 1896, 1898, and a special report was issued in 1899, accompanied by a forestry map. The principal questions investigated relating to this subject were:

1. Location, extent, and quality of the forest areas.
2. Rate of growth as compared with cutting.
3. Forest fires, their cause, the damage occasioned, and their prevention.
4. Effects of deforestation upon stream flow, stream pollution, and floods.
5. Effects of insects on forests.

Topographic work.—In 1873 the old New York-New Jersey boundary was resurveyed and marked with appropriate monuments. About 1878 there was begun a State topographical atlas on a scale of 1 inch to the mile. This was finished in cooperation with the United States Geological Survey in 1887, forming an atlas of 20 sheets. The entire cost of this work was $54.744, exclusive of engraving and printing the maps, or $6.93 to the square mile. Through the cooperation of the State with the national organization the expense to the State was reduced to less than half that sum. New Jersey, it may be stated, was the pioneer in this cooperative work.

In 1898 a new series of topographic maps on a scale of 2,000 feet to the inch was begun.

Scientific and educational.—Much attention was given to the study of the geologic structure of the State, the order in which the formations occur, their thickness, lithological character, and fossils, if any, and the conditions under which they were formed. Much of this work has a direct economic value.

The rocks of the Kittatinny Mountains and Valley, the Green Pond Mountain region, the red sandstone belt, and the Cretaceous clays, sands, and marls have thus been studied. The crystalline rocks of the highlands have also been studied, in cooperation with the United States Geological Survey. The glacial deposits have likewise been studied, and a full report issued, forming volume 5 of the present organization.

In 1895 a report upon the physical geography of the State and its development was issued, the same forming volume 4 of the final report of the series. This report was accompanied by a photo-relief map of the State.

The fossils of the marl beds were studied by Prof. R. P. Whitfield under Doctor Cook's direction, the results being published in two volumes, by cooperation with the United States Geological Survey.

In the annual report for 1881 a discussion of the climate of the State was presented.

Salaries and expenses.—From 1864 to 1895, inclusive, a definite sum was appropriated in four or five year periods for salaries and expenses. In addition to this the board of managers had authority to publish maps and reports, the cost of which to any amount were paid by the State treasurer without specific appropriation until 1895, when the amount was limited to $5,000 annually, making the total annual appropriation at that time $13,000. Previous to 1891 unexpended balances were carried over to the next year, since which date they lapse. Furthermore the annual reports, being a part of the legislative printing, have been paid for in the main, at least, from the fund for that purpose, and not charged to the geological survey.

Messrs. Cook and Smock each received a salary of $3,000 a year. The assistants were paid on a daily basis, amounting in some cases to $600, and in others to $2,000 a year. The following table shows the appropriations and expenditures for the years 1864–1900.

Year.	Appropriation.	Geological.	Publication account.	Forestry and printing (legislative fund).	
				Special.	Reports.
1864	$20,000	$1,350.00			
1865		5,620.38	$283.03		
1866		3,999.07	931.95		
1867		5,135.31	1,355.08		
1868		3,804.24	4,562.05		
1869	20,000	2,395.97	8,244.86		
1870		5,662.84	1,828.39		
1871		5,512.41	1,170.00		
1872		4,800.34			
1873	20,000	4,609.56	339.10		
1874		5,638.38	1,984.50		
1875		4,853.72	242.75		
1876		5,022.07	1,114.80		
1877	8,000	7,447.97	577.25		
1878	8,000	8,175.86	257.51		
1879	8,000	8,634.84			
1880	8,000	8,059.89	70.11		
1881	8,000	6,994.97			
1882	8,000	6,819.32			$5,080.82
1883	8,000	8,024.60			1,654.53
1884	8,000	8,887.85			
1885	8,000	8,216.28	[1] 5,546.82		
1886	8,000	7,659.54	9,200.45		
1887	8,000	5,217.97	15,222.42		
1888	8,000	8,030.74	10,507.31		1,020.80
1889	8,000	7,677.81	5,044.79		4,853.72
1890	8,000	5,582.87	7,365.18		
1891	8,000	9,039.32	6,155.49		3,261.38
1892	8,000	8,000.00	6,634.35		7,972.60
1893	8,000	8,000.00	3,231.34		[2] 6,122.72
1894	8,000	8,000.00	4,654.15		13,569.01
1895	18,000	8,000.00	4,810.51	$4,854.93	[3] 17,657.72
1896	13,000	8,000.00	4,657.16		5,725.23
1897	15,000	7,992.47	5,000.00	1,816.44	2,480.42
1898	13,000	7,999.67	4,999.68		2,745.83
1899	13,000	7,996.01	5,000.00		10,459.83
1900	13,000	7,999.97	4,999.71		1,300.00
Total	$289,000	$244,292.24	$125,993.74	$6,671.37	$83,904.61

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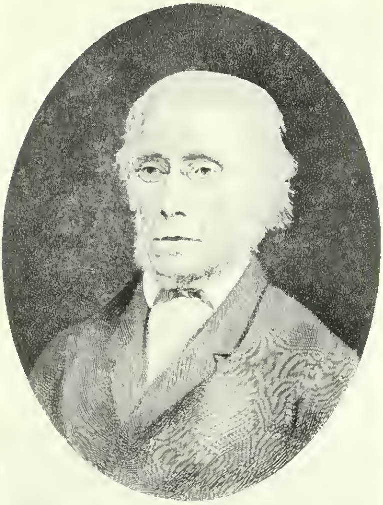
[1] Chiefly engraving and printing topographical atlas; also for 1888, 1889, 1890.

[2] Vol. 3 and Annual for 1894.

[3] Vol. 4 and Annual for 1895.



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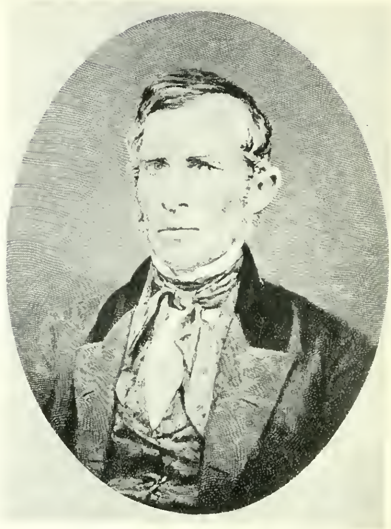

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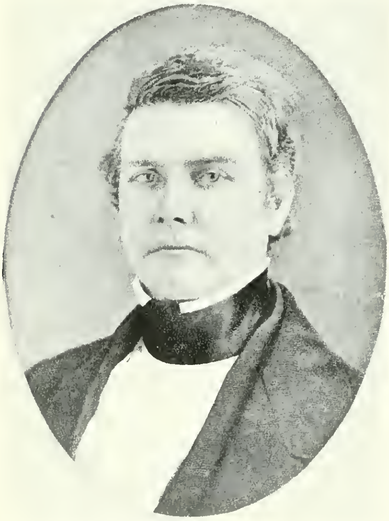

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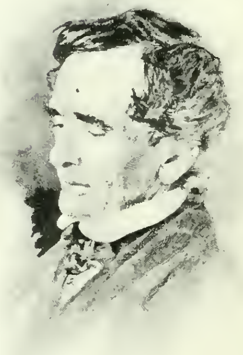

LARDNER VANUXEM

STATE GEOLOGISTS OF NEW YORK, 1836-46.

NEW YORK.

The history of the New York State surveys can not well begin without reference to the pioneer work of Amos Eaton, who began his scientific career in 1816, and in 1818, on the invitation of Gov. De Witt Clinton, delivered a course of lectures on natural history before the members of the State legislature. In 1821, under the patronage of Stephen Van Rensselaer, he made a geological and agricultural survey of Rensselaer County, and later (1824), under the same auspices, a survey of the district adjoining the Erie Canal. These surveys, together with his textbooks and other writings, served to arouse the interest of the public, and to him doubtless more than to any other one man was due the early establishment of a survey under State auspices.

GEOLOGICAL SURVEYS UNDER HALL, EMMONS, AND OTHERS.

As early as 1827 among the laws of the State is the following:

> 4. *And be it further enacted*, That for the purpose of encouraging mineralogical researches it shall and may be lawful for the said commissioners of the land office to grant to any discoverers of mines, minerals, and fossils, other than gold and silver, such lands as they may apply for, not exceeding 500 acres of land, without estimating in the valuation thereof the said discoveries, and retaining to the people of this State one-half of any land in which such mines, minerals, and fossils may be discovered.

It was not, however, until 1835 that the subject of a State survey assumed a definite form. In that year it appears the Albany Institute of New York presented a memorial to the legislature, which seemed to have formed the basis for subsequent action. The immediate result of this memorial was the following resolution by the house of assembly:

> *Resolved*, That the secretary of state be requested to report to the legislature at its next session the most expedient method of obtaining a complete geological survey of the State, which shall furnish a scientific and perfect account of its rocks, soils, and minerals, and their localities; a list of all its mineralogical, botanical, and zoological productions, and provide for procuring and preserving specimens of the same; together with an estimate of the expenses which may attend the prosecution of the design, and the cost of publication of an edition of 3,000 copies of the report, drawings, and geological map of its results.

On the 6th of January of the following year, John A. Dix, then secretary of state, submitted an elaborate report upon the subject.[1] Realizing that "the principal object of the survey is to procure information which may be applied to useful purposes, it is desirable to complete the work as soon as possible in order that the results may be available at the earliest practical date," he proposed that the

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[1] Report of the secretary of state in relation to a geological survey, Jan. 6, 1836.

State be divided into four districts, and to assign to each district two geologists and a skilled draftsman. The first district was to comprise all the easternmost counties of the State from Washington southward—an area of 12,263 square miles; the second, the northern tier of counties from Lake St. George to the St. Lawrence River—an area of 9,692 square miles; the third, the central group of counties including the salt springs—an area of some 12,293 square miles; and the fourth, those counties in which a continuation of the coal formations of Pennsylvania was to be expected—an area of 11,594 square miles.[1]

In addition to geology it was proposed to include zoological and botanical surveys. The proposed organization is tabulated below:

Two geologists in each district, at a salary of $1,500 a year each—4 districts, 8 individuals	$12,000
One draftsman to each district, at a salary of $800 a year—4 districts, 4 individuals	3,200
One zoologist for the whole State, at $1,500 a year	1,500
One draftsman for the whole State, at $800 a year	800
One botanist for the whole State, at $1,500 a year	1,500
One draftsman for the whole State, at $800 a year	800
Packing and transporting specimens	100
Total annual expense of proposed survey	$19,900

An appropriation of $20,000 a year for four years would, it was thought, certainly cover the whole expense of making the survey.

The cost of publishing 3,000 copies of the report, drawings, and map of the results, was estimated as follows:

It is supposed that the entire account of the survey may be contained in three volumes, 8vo., of 700 pages each, 3,000 copies; 9,000 volumes, in boards, at 81 cents each	$7,290
The maps may be lithographed, and with the necessary drawings of fossil remains, will not exceed $4.33½ per atlas—3,000 copies	13,000
Coloring of maps will be additional charge of, say	3,000
Cost of fitting up cabinet for specimens	1,000
	$24,290

It will be observed that the survey thus planned comprised the entire field of natural history and was to be independent of any other institution; and, further, was to be supported by annual appropriations of $26,000, or $104,000 for the four years. For reasons explained later the survey with enlarged scope was extended several years beyond the original intended limit and the ultimate cost to more than four times that first estimated.

It was proposed also to preserve for a State cabinet specimens of natural history and mineral products, for which purpose it was thought a room might be found on the third floor of the capitol building.

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[1] This subdivision is stated to have been made on the advice of Prof. Edward Hitchcock. American Geologist, vol. 16, 1895, p. 138.

It was in accordance with this report and recommendation that the following law was enacted:

An act to provide for a geological survey of the State.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

1. The governor is hereby authorized and directed to employ a suitable number of competent persons, whose duty it shall be, under his direction, to make an accurate and complete geological survey of this State, which shall be accompanied with proper maps and diagrams, and furnish a full and scientific description of its rocks, soils, and minerals, and of its botanical and zoological productions, together with specimens of the same; which maps, diagrams, and specimens shall be deposited in the State library; and similar specimens shall be deposited in such of the literary institutions in this State as the secretary of state shall direct.

2. The sum of $26,000 is hereby appropriated annually for four years to defray the expenses that may be incurred under this act, which sum shall be paid by the treasurer on the warrant of the comptroller in such manner and at such times as the governor may direct.

3. The person or persons employed by the governor for the purposes mentioned in the first section of this act shall make a report annually to the legislature, on or before the first day of February in each year, setting forth generally the progress made in the survey hereby authorized.

This act was followed by others as given later.

Administration.—The suitable number of competent persons to carry out the conditions of the law as appointed by the governor, included W. W. Mather, of Connecticut, in charge of the first district; Ebenezer Emmons, of Williams College, of the second; Timothy Conrad, of Philadelphia, of the third; and Lardner Vanuxem, of Bristol, Pennsylvania, of the fourth.[1] The mineralogical department was assigned to Prof. L. C. Beck, of Rutgers College, New Jersey; the botanical to Dr. John Torrey, of New York City, and the zoological to Dr. James E. De Kay, of Long Island.

By the end of the first season it had become apparent that the work could be more readily accomplished by discontinuing the appointments of assistant geologists and through the appointment of one person as paleontologist of the entire survey. Timothy Conrad was therefore appointed to this latter position, while James Hall, who had served as assistant to Emmons, was made geologist of the fourth district, Lardner Vanuxem being incidentally transferred to the third.

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[1] It is said in the American Geologist, vol. 16, 1895, p. 138, that Edward Hitchcock was first appointed to take charge of the survey with C. D. Adams as assistant, but that he resigned in order to devote his attention to the resurvey of Massachusetts. This statement is also made in the elder Hitchcock's History of Amherst College.

The annual compensation suggested for each geologist was $1,500. When later it developed that some of those employed could not devote their entire time to the work, such were paid $1,200 a year. The assistants were to receive $800 a year, and each geologist, zoologist, botanist, and mineralogist was to receive $300 in addition to salary for executing the necessary drawings, packing specimens, and for the expenses of concentrating such at places convenient for transportation to Albany. These rates of compensation seem to have remained as fixed throughout the existence of the survey, although naturally the total expense of any one department was greater some years than others. The expenses for 1838, under these conditions, are given on page 335.

Work continued under the law of 1836, as above outlined, without serious complications until 1840, the limit set for the life of the organization. During this time annual reports were issued, and a casual inspection would lead one to suppose that the survey might readily have come to an end at that period. It was found, however, on investigation that such was by no means the case, an investigating committee reporting under date of April 28, 1840:

> The condition of the survey is such that it will be utterly impossible to complete it in a manner commensurate with its object and the character of the State during the time originally assigned for its completion. Several counties are yet entirely unexplored and several others only partially explored. The constant labor of the geologists will be required in the field until next November. The winter season following will be required for making the annual report and arranging the collections in the building which shall be appropriated for that purpose. The season following will be required for a reexamination of some portions of the State, for supplying any deficiencies which shall be found to exist in the collections after their arrangement, and for the preparations of maps, sections and other drawings, together with the final report. The amount of labor to be done in the field, the arrangement of the collection, and the preparation of the report will render it quite impossible to complete it with any degree of perfection in a shorter period of time. * * *
>
> From this brief sketch of the condition of the survey it is very evident to your committee that an abrupt discontinuance of it at the expiration of the time contemplated in the original plan would greatly injure its usefulness and dishonor the whole enterprise. It is believed it will require no further appropriation to complete it, and they have therefore come to the conclusion that it will be carrying out the views of the legislature which authorized the survey, and meet the approbation of the people, to authorize its continuance until the first Tuesday in January, 1842.

It was in accordance with this recommendation that the following act was passed:

An act to continue the geological survey of the State, passed May 8, 1840.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

1. The governor is hereby authorized to continue the geological survey of the State, in the same manner in which it has heretofore been conducted, until the

first Tuesday in January, 1842: *Provided*, The expense shall not exceed the unexpended balance of moneys appropriated for the survey by the act passed April 15, 1836.

Under this act the survey was continued as before, the fifth and last annual report bearing date of 1841, when the various geologists turned their attention to the final reports, those of Emmons and Vanuxem being issued the year following (1842). The reports of Hall and Mather would appear, however, not to have been completed within the limit set, and on April 9, 1842, another extension was granted, as follows:

An act relating to the geological survey of the State, passed April 9, 1842.

The People of the State of New York, represented in Senate and Assembly, do enact as follows:

1. The governor is hereby authorized to continue, until the first Tuesday in January, 1843, such of the various departments of labor connected with the geological survey of this State, as may be necessary to insure its ultimate completion and publication according to the plan heretofore contemplated.

2. The sum of $26,000 is hereby appropriated to pay any money now due for materials furnished or services rendered under the act passed May 8, 1840, entitled "An act to continue the geological survey of this State," and to defray such expenses as may be incurred under this act.

3. The secretary of state is hereby directed to secure a copyright of the geological survey for the benefit of this State.

4. Whenever two or more volumes of the geological survey shall be published, the governor and secretary of state may cause such books to be sold at such prices as they may deem expedient, and any moneys derived from such sales shall be applied to the same purposes as the appropriation made by the second section of this act.

5. The geological survey, as fast as completed (except such volumes as may be sold according to the provisions of section 4), shall be distributed as follows: Two copies to the governor; two copies to the lieutenant governor; one copy to each member of the present legislature; one copy to each of the geologists engaged in said survey; three copies to the State library; one copy to each county clerk's office in this State; one copy to each incorporated college in this State; and the remaining copies shall be deposited in the office of the secretary of state to be sold or disposed of in such manner as the legislature may hereafter direct.

6. The concurrent resolution of the senate and assembly, passed May 26, 1841, in relation to the distribution of said geological survey is hereby repealed.

7. This act shall take effect immediately.

Even with the expiration of the limit set by this act the work was still unfinished, and on April 8, 1843, a supplemental act was passed, as follows:

An act in relation to the natural history of New York, passed April 8, 1843.

The people of the State of New York, represented in senate and assembly, do enact as follows:

1. The governor is hereby authorized to continue such of the various departments of labor connected with the geological survey of this State as may be

necessary to insure its ultimate completion and publication according to the plan heretofore contemplated, and to contract with the printers to the assembly for the publication of the same at prices advantageous to the State.

2. The treasurer shall pay on the warrant of the comptroller the necessary cost and expenses already incurred or hereafter to be incurred in the completion of the said work, to the person or persons entitled to the same, out of any moneys in the treasury not otherwise appropriated.

3. The governor is hereby authorized to continue the services of one or both of the geologists who are now residing in Albany for the purpose of completing and arranging the said collection of specimens in the old State hall, and doing any works connected therewith he may deem necessary.

4. Whenever two or more volumes of the said work shall be completed, the governor and secretary of state may cause such books to be sold at such prices as they shall deem proper, not less than $2 per volume, and any moneys derived from such sales may be applied to the payment of the geologists for any debt due them from the State on account of services connected with said work.

5. The volumes to be published shall be uniform with those already published and of as good materials.

6. This act shall take effect immediately.

By the first section of this act it will be noted that the governor was authorized to continue such of the departments of labor connected with the geological survey of the State as might be necessary to secure its ultimate completion and publication according to the plan heretofore contemplated. The final reports of Hall and Mather appeared during this year (1843), and may be said to mark the limit of the first survey. But by the third section of the act the governor was authorized to continue the services of one or both of the geologists then residing in Albany (Hall and Emmons) for the purpose of completing and arranging the said collections of specimens in the old State hall, and doing any work connected therewith he might deem necessary. By section 2 of the same act all limit of expense was removed from a further prosecution of the work. Under the license of this act Governor Bouck entered into the following contract with Ebenezer Emmons and James Hall.

The undersigned hereby propose and engage to make the necessary survey and examination, prepare the reports, superintend the drawings, engraving, and printing, and binding, to complete in all respects, and publish the geological survey of the State to its ultimate completion, according to the plan heretofore contemplated and as indicated in the annexed paper signed by us.

As far as it may be practical, in the opinion of the governor, the work is to progress in such manner as will insure its completion in May or June, 1844. This proposition is to include every kind of labor and expense necessary to a full completion of the geological survey in all the departments excepting the printing, coloring the map, drawing, and engraving, and the employment of one assistant geologist the 1st day of June, 1844.

The services and expenses indicated by this proposition are to be performed for a compensation equal to a salary of $1,500 for each of us, and a sum not exceeding $500 for the assistant, unless the time occupied by each of us should be less than one year and that of the assistant less than five months, in which case there shall be a corresponding reduction, but under no circumstances is a larger sum to be paid.

Under this contract Professor Hall undertook the preparation of his comprehensive works on the paleontology of the State and Professor Emmons began an agricultural survey, neither one of which was contemplated by the original plan, and which later aroused considerable criticism on the part of the legislators.

By the close of 1845 it appears that under this last arrangement nine volumes of reports had been printed, and it was estimated that six more would be requisite to complete the work. There had thus far been expended $311,321.72, and an addition of $54,268.92 was estimated as needed to carry the project through. In this year Governor Wright entered into a further contract with Professor Hall for the completion of the geological work with the specific understanding that the time requisite should not exceed two years, and his salary be continued at the rate of $1,500 a year. Professor Emmons reported this year to the assembly committee that for the volume on agriculture, then under his charge, 100 pages had been printed. He also was allowed a continuation, with a salary at the rate of $1,500 a year up to October 1, 1846. On the meeting of the assembly in 1847 the work of neither Hall nor Emmons was completed and more time and more money was asked. After an investigation the joint committee reported the following bill by which both departments were continued for two years at the same salaries as heretofore, and the sum of $25,000 appropriated. The following is the text of the bill:

An act for completing the publication of the natural history of New York, passed May 7, 1847, "three-fifths being present."

The people of the State of New York, represented in senate and assembly, do enact as follows:

The governor is hereby authorized to cause to be completed, and for that purpose to continue in employment the geologists now engaged upon that portion of the natural history of this State relating to agriculture and to paleontology for the period of two years from the time when their salaries ceased under an arrangement with Governor Wright, and for no longer period or term than above mentioned, and at the same salary as has been hitherto paid them.

2. The governor is also authorized to contract for all the work connected, such as drawing, engraving, coloring, and all other necessary work connected therewith, to be done in such manner as he shall direct.

3. The treasurer shall pay on the warrant of the comptroller the costs and expenses already incurred or to be hereafter incurred in the completion of said works to the person or persons entitled to the same out of any moneys not otherwise appropriated, but no such account shall be paid unless the same be certified as being correct by the governor of this State.

4. The sum of $25,000 is hereby appropriated for the purposes of this act.

5. Should either of the present geologists decline acting, the governor is authorized to employ some other person for the same purpose.

6. This act shall take effect immediately.

Under this act Professor Emmons's term of service expired on October 1, 1848, and Professor Hall's on April 1, 1849, but neither brought his work to completion within the time limits set. The chief causes for this continual extension, in both time and expense, were thus stated in the report of the assembly committee for 1849–50:

Some of the causes are very obvious:

1. The original plan of survey was very closely adhered to, and the expense of the survey was within the limit up to 1840. The estimate was exceeded in respect to the time necessary for the field. One year and a half more proved requisite.

2. The whole original plan of publication was departed from, instead of 3 volumes octavo there are to be 20 volumes quarto. In 1842, when the quarto size was determined on, it was supposed eight volumes would be the number.

3. The addition from time to time of new departments to the work. Paleontology and agriculture alone add eight volumes not originally contemplated.

4. In the increase of illustrations and the amount of coloring will be found the great cause of expense. To the former, including the atlas, was assigned $13,000 by the original plan; and of coloring, none was contemplated to be done, except in the case of the maps, which it was supposed $5,000 would cover.

There has been an exceeding looseness about the making and preservation of contracts relating to certain parts of the work. By several of the governors verbal contracts have been made and verbal directions given, about which their successors could have no knowledge from the papers left in the State departments. The embarrassments under which successive governors have labored from an ignorance of the acts of their predecessors is very apparent to anyone who examines their certificates attached to the different warrants. Your committee believe it would be well if by law it was rendered requisite to the validity of every executory contract made with the State, that it should be in writing and duly signed. There should, moreover, be a common and sole depository for contracts made with the executive of the State. Of the contracts relating to this work, some have been found in the executive department, some in the comptroller's, and several nowhere.

Very much of the difficulty that has attended the progress of the natural history, and much unnecessary expense has arisen from the absence of uniform control. Governor succeeded governor, and after a few years had elapsed from its commencement, no one of them could be expected to know, or could anyone be familiar with the details of the past progress of so extended a work, which would be necessary to enable him properly to direct its present and provide for its future. Thus deviation after deviation occurred from the original plan. Your committee are led to the belief that the control and direction of a work of this kind would be more properly vested in some literary or scientific board of a permanent character than was the executive overcharged with other business and liable to frequent change.[1]

In asking for a further continuation this year it was estimated that in all $150,000 would be needed. Hall thought to be able to complete his work in five years, while Emmons found it "impossible to fix the time it will take to complete the letterpress of the work in his department as accurately as he wishes." Up to this time the actual amount paid out on warrants on the survey account was $425,844.74, as itemized below.

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[1] See report of the select committee of the legislature of 1849 on the publication of the Natural History of the State of New York, made to the legislature January 22, 1850, for full details. Assembly document, 73d session, vol. 1.

Expenses.—The estimated annual expenses of the survey as given by Secretary Seward in 1836 were $24,290. The actual expenses for 1838 were as follows:

John Torrey, in botany, salary	$1,200	
Allowed for drawings	300	
		$1,500
Lewis C. Beck, M. D., in mineralogy, salary	1,200	
Allowed for drawings	300	
Allowed for assistance and some expenses	150	
		1,650
James E. De Kay, in zoology, salary	1,500	
Allowed for drawings	300	
		1,800
John W. Hill, in zoology, employed as draftsman		800
Timothy A. Conrad, in paleontology, salary	1,500	
Allowed for drawings	300	
		1,800
William W. Mather, (first district), in geology, salary	1,100	
Allowed for drawings	300	
Allowed for cases of specimens	175	
		1,575
E. Emmons (second district), in geology, salary	1,500	
Allowed for drawings	300	
		1,800
Lardner Vanuxem (third district), in geology, salary	1,500	
Allowed for drawings	300	
		1,800
James Hall (fourth district), in geology, salary	1,500	
Allowed for drawings	300	
		1,800
Total		$14,525

The total expenses of the survey during the four years ending July 1, 1840, when it was expected to come to an end, was $72,982.12. It had become evident by this date, however, that the work could not be satisfactorilly completed within the limits set, and an extension was asked of 18 months, which was granted, as already noted, with the understanding that the additional expense should not exceed the unexpended balance of money appropriated by the original act, namely, $104,000. Through an error in bookkeeping it later developed that this amount had been already exceeded by $228.80, with considerable still due on salaries and publication of reports as yet unprovided for. It was then estimated that the sum of $45,363.90 additional would be required.

On April 9, 1842, and January, 1843, additional appropriations of $26,000 each were made. The total cost of the survey and results up to February 6, 1844, when the survey proper may be said to have come to an end, and as given in the report of the secretary of state, is as follows:

Statement of moneys paid out of the treasury on account of the geological survey of the State of New York, viz:

For surveying and attendant expenses	$116,970.65
For engravings and attendant expenses	50,678.05
For printing and binding	44,223.21
	$211,871.91
Add for printing annual reports, 1836–1841	19,530.30
Fitting up geological museum	4,500.00
Total	$235,902.21

The select committee appointed by the legislature of 1849, to inquire into the affairs of the survey presented the following table showing the total amount of expenditure:

Part I, showing persons.

Professor Torrey	$9,025.00	Thurlow Weed	$40,723.11
Professor Vanuxem	11,022.93	Packard, Gavit & Co	5,378.84
Professor De Kay	13,550.00	George Endicott	127,399.97
Professor Mather	12,503.82	R. H. Pease	11,293.35
Professor Beck	13,098.25	John H. Hall	14,895.50
Professor Conrad	9,225.00	Gavit & Duthie	8,659.32
Professor Emmons	23,162.04	E. Emmons, jr.	20,100.00
Professor Hall	25,062.10	F. J. Swinton	307.50
Drawing allowances	6,564.50	Draper, Toppan & Co.	614.00
Geologists' assistants	13,842.78	Specimens of engravings	601.30
Museum	2,979.08	Original drawings, not included in payments to any of above	3,869.21
Transportation	3,126.44		
Miscellaneous	491.38		
Carroll & Cook	33,889.18		
Van Benthuysen & Co.	14,460.14		$425,844.74

Part II, showing subjects.

Professors' salaries, etc.	$116,649.14	Wood engravings	$20,363.35
Professors' drawing allowances	6,564.50	Printing, letterpress, and binding	89,072.43
Geologists' assistants	13,842.78	Coloring	73,212.00
Museum	2,979.08	Lettering	496.00
Transportation	3,126.44	Printing impressions of plates	38,582.93
Miscellaneous	491.38	Paper	25,414.20
Original drawings	8,360.71		
Steel engravings	9,871.80		
Stone engravings	16,818.00		$425,844.74

The actual amount paid out by Governors Marcy and Seward, and by warrants is $425,375.76.[1] The probable reason for the difference ($488.98) is shown in the report.

The following letters relating to the subject are of sufficient interest to warrant reproduction entire:

CAMBRIDGE, *July 22, 1849.*

MY DEAR SIR: I understand from Doctor Gould that you [*i. e.* Hall] have soon to report progress before a committee of the house upon your paleontology and that there are those who complain of the slow advance you make. I regret deeply that I have no direct connection with your committee, as it would afford me great pleasure to explain to them various things about it. Can a private letter be of any use to you to bring this before them? In the first place, let me remark in a general manner that it is deeply to be regretted that with the most liberal dispositions legislative bodies and governments scarcely ever understand the wants of science; and having no opportunities of intercourse with men of science, I do not mean professional men in scientific professions, but men of original research, they can not understand fully how science can be promoted, and make often the greatest blunders with the best intentions. It is unpleasant to say, but it is so, and unless you can make your people understand that no investigation can be hurried, you will never have independent investigators in this country, and the few who prefer their scientific reputation to any position in society will be left to struggle with never-ending difficulties. I have seen your collections, your drawings, your preparatory investigations, and I must say that I have never seen more labor better done in so short a time. Science shall be forever indebted to your State, if you prevail upon your legislature to grant you time and time and time to accomplish the task you have so beautifully conducted up to the present day. Your first volume is valued in Europe as the largest and best recent contribution to geological science, and it is a pity there is no scientific tribunal here to ackonwledge it. If I was an American I would appeal to my country to shake off this dependence upon European authority for appreciation of American works, and I only mention it now to induce your political friends to rely more than they have been in the habit of doing upon the testimony of your best scientific men.

I am not in the habit of appealing to authority, but I say *bono auctori sit auctoritas*, and until there are men in America whose authority is acknowledged in matters of science there will be no true intellectual independence in America, however great be their political freedom. Is it not a shame for instance, that you, you, Professor Hall, should feel anxious about showing that you could not have written more than one volume in two years. Come forward with Cuvier's Ossemens fossiles, or Goldfuss Petrefacten, or any other work of the same kind, and compare them with your own volume, and point with legitimate pride to the date of publication of the successive volumes of those works, and you will silence every remark. If your engravers are troublesome and unwilling to do the work to that degree of perfection which is now required in such publications, send them away and have others come from Europe. They will be happy to come at present, under the disturbed circumstances that have interrupted so many splendid publications; but for mercy sake for the dignity of our science, do not allow such individuals to boss you. If you want him I will find for you an artist who will engrave your fossils from nature, almost without an original drawing.

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[1] This sum ($425,375.76) does not include the amount paid for printing the geologists' annual reports from 1836 to 1841, $19,530.30 (comptroller's report of 1844), nor the value of the lot and building for museum, $25,000 (comptroller's report of 1847).

If you have d'Orbigny's Paleontology française at hand, you can tell your committee that the lithographer, Mr. De la Rue, never had other original drawings before him except such offhand sketches as were necessary to arrange the figures of a plate, and nevertheless how beautiful his figures are. So was Hobe never provided with more than simple sketches for the magnificent work of Goldfuss. Let that be known and repeated everywhere, and you will soon be left quiet. Is it not a pity that an engraver who never had anything to do with such drawings before should now come forward and stand against you with his pretenses? Give him up simply; you can not progress with one who will not submit to your directions.

* * * * * * *

Your sincere friend,

(Signed) L. AGASSIZ.

MARCH, 1849.

Hon. Mr. BEACH.

DEAR SIR: At your request have prepared a statement of the amount of engraving necessary to complete the report on paleontology.

I wish, however, to say a few words in explanation of the past transactions in regard to this part of the survey. In 1843, after the resignation of Mr. Conrad, Governor Bouck had decided to bring the survey to a close in one year and required that this part should be done in that time. I signed the agreement, though protesting against it as not giving time to prepare a proper or authentic work on this subect. In the course of that year, however, I did prepare materials for a single volume, but as the specimens were obtained from all the formations nothing had been thoroughly done, and had the work been completed at that time and in that manner, it would have been discreditable to the State and to myself, as well as being of no authority in the science.

Subsequently, and when the time was extended, I devoted myself to the investigation of the lower rocks, and from them I have obtained all the species described in the present volume. At the time of my engagement with Governor Wright I sincerely believed that the work could be completed in about two years and the number of plates in all would not exceed 150. At this time I had allotted to the fossils of the lower rocks, comprising the Potsdam sandstone, Calciferous sandstone, Chazy, Birdseye, Black River, and Trenton limestones, Utica slate and Hudson River group, about 50 plates. The result of a thorough investigation has shown that very nearly 100 plates are required properly to represent these fossils.

I conceived it to be the object of the State in this matter to make the work as perfect as it can be made under existing circumstances, and I have therefore examined with the greatest care every fossil that has fallen under my observation. I believe I have made the volume already printed as perfect and complete in every part as this one, and should the work be suspended before the whole is completed in this manner I propose that as far as I do go to work up the materials from each rock in its order in the same thorough manner that so far as I shall have gone it may be satisfactory and creditable as well as of sufficient authority to be cited hereafter.

I have already made myself considerably acquainted with the fossils of the higher rocks and have about 30 plates already engraved in wood and lithography. I have carefully gone over each rock and estimated the number of plates which will be required to finish the whole in the manner I propose and in as complete a manner as the volume already printed is done. I find this number will be scarcely less than 250, and it can not vary 10 plates from this number.

This amount is much larger than I ever anticipated, but you can readily understand why it is so. Until the work was commenced so little was known of the matter that it was impossible to estimate with any certainty the number of plates required. The increased number of plates arose from the discovery of a great number of species of fossils before unknown, which in the volume published has been more than quadrupled since the work began. For the same reason the time originally regarded as sufficient has been extended from necessity, and there are already engraved as many plates as it was supposed originally would be required for the whole work. But I repeat that no person could have anticipated this from the commencement and no better estimate could have been given at the time.

In regard to time in future, I shall state very frankly that, if this work is to be completed as I propose it can not be done in two years. Had there been no legislative action at this session I proposed to complete the second volume and present it to the legislature at its next session, showing that the amount of work actually done was more than originally contemplated for the whole.

Under present circumstances I must abide the decision of the committee in relation to the subject.

* * * * * * *

(Signed) James Hall.

Albany, *November 20, 1849.*

Hon. Nelson J. Beach.

Dear Sir: * * * Since you may not be aware of the reasons why I need more room than I have at present, I will briefly state my objects. In the first place, I collect from different and distant localities. When I open my boxes and arrange the specimens it is not sufficient to have a single good specimen from any one locality, but I wish to have before me several specimens from different localities to compare. I want, in fact, a geographical collection of the species, that I may see their greater or less importance or preponderance in certain localities, their condition arising from the conditions of the ocean, and the variations in form, size, etc., as indicating more or less favorable circumstances for their growth. I wish also to observe whether the grouping or congregating of certain species continues through wide areas or not, as well as numerous other facts, only to be ascertained by having an extensive collection before me. It is acknowledged on all hands that the manner in which palaeontology has heretofore been studied it has been of little avail. I wish to have the palaeontology of New York take a higher position and to be in some sort an equivalent of the liberality of the State government.

I can not forbear at this time to call your attention to these facts in other bearings. The State of New York is publishing a work on the natural history of her territory which is exciting more attention at home and abroad than all else she has ever done. Already is the work sought after in all parts of Great Britain and from Rome to St. Petersburg on the Continent of Europe—from every State in the Union come letters expressing the strongest desire to obtain the work. The man who laid the foundation of this work has earned himself a reputation undying, and the several legislatures of the State have with exceeding liberality carried out this plan. I would ask you, however, if there are not other influences in operation which, though they can not materially affect the work at present, will nevertheless subvert much of the good results. Instead of any endeavor being made to enlist those engaged in the work, in its permanent, constant and future advancement, and in the perfection of a collection which must ever remain the standard one for the country, the expressions are "How soon can we get rid of you and why can you not complete the work in one year as well as a longer time?" The interest which one feels is alienated by such a course, and the constant annoyance from petty remarks, joined with a conviction that as soon as possible we shall be dismissed from the work, renders the instinct of self-preservation active in devising ways of accomplishing its objects and in providing against future contingencies.

In order to accomplish such a work, your scientific men should be left perfectly quiet, and every facility afforded for their progress. If their own interest in the subject, and a proper regard for their scientific reputation will not induce them to progress with the work as rapidly as is consistent with its perfection or utility, rest assured that no other measures, however annoying or harassing they may be, will ever effect the objects.

Of course, I must admit that those persons who have the direction of these collections know what objects are desirable to be attained and will take the proper measures to accomplish the end. But I must call your attention to the condition of the several sciences embraced in this work. The sciences of zoology and botany are in a state of such advancement that there appears little room for new discoveries or great progress except in organic analysis, which is the province of chemistry. On the other hand, in geology embracing both mineralogy and paleontology, there is far more room for discovery and much research is yet required—on the one hand, among the metamorphic rocks, and the changes which all strata undergo by subsequent influence, and on the other hand, the problem of the development and the successive appearance of races on our planet—are subjects in which the deepest interest is felt, and concerning which comparatively little is yet known.

Without going into further detail, I wish to show you the necessary consequences of alienating the feelings and interest of those persons engaged in the perfection of a work like that already commenced. The moment that the persons who have been engaged in this work shall cease their connection with it, and the charge of it go into the hands of curators knowing little of the progress of the work and of what has been done or yet remains to be accomplished, your collection becomes, if I may use the expression, a dead one. It will no longer possess the interest it now does, for it will cease to advance, and in ceasing to advance other collections and other individuals will soon be in advance of you. I need not go into detail of all the reasons and facts to convince you of this. Let me cite a single case. While Professor Agassiz remained at Neufchatel, every eye was directed there to learn from him as the master what were the laws, the facts, and the results in most departments of zoology; the collections of Neufchatel bore the stamp of authority, and the place, though comparatively an obscure one, was the center of advancement in science. Professor Agassiz is no longer at Neufchatel but at Harvard University, and where now does the world look for the advancing of natural history and the promulgation of laws before unknown? Not to Neufchatel, but to Harvard University, where science is to take the lead of the world.

Now, sir, New York has made progress in all the sciences, but in geology she stands preeminent and her localities will be classic ground for centuries to come, but the scepter may depart and I say unhesitatingly that the course likely to be pursued as that already manifested, will prevent any further progress, and in all probability New York will be in 50 years hence just where she now stands, while science will have made mighty strides, and the vantage ground she now holds will be given up, indeed thrown away, from mere ignorance and ill nature.

I speak without any selfish motives in saying what I have done, for I unhestitatingly aver that I have no ulterior objects beyond completing the work I have in hand in a creditable and satisfactory manner. I wish to feel a lasting interest in the future progress and the continual approximation of the collection to perfection, but as I before said, it is impossible to feel any interest when a desire to prove that interest constantly involves me in difficulties, and I am made to feel that I am only wanted for a little time, and the shorter that time and the more annoyances I am made to suffer, the more perfectly will the interests of the State be served.

I commenced the work with all the zeal of a devotee, and thus pursued it till I found myself compelled to look to self-preservation, and I freely confess that it is impossible to keep up such an interest without a slightly corresponding interest in those who have the power at least to annoy me.

I have wandered from the subject, but I could not avoid saying what I have done, and I might say much more, but there may be other occasions.

I ask your advice as a senator of the State, as one of the chief officers of the public works, whether I shall continue to work here under the disadvantages I have mentioned, when the adjoining room, almost wholly unoccupied and of no importance to anyone, is denied me—or whether provision is to be made at my private expense for the necessary accommodations for the performance of my duties.

I am, with sentiments of esteem and respect,
Very sincerely, yours.

(Signed) James Hall.

The six following acts relate only to the distribution of the reports of the survey:

State of New York,
In Senate, May 26, 1841.

Resolved, (if the Assembly concur), That the report of the geological survey of this State, when completed shall be distributed as follows: Five copies to the governor: five copies to the lieutenant governor; one copy to each member of the senate and assembly, and to the several officers of the same; one copy to each of the several State officers; three copies to the State library; one copy to each county clerk's office in this State; one copy to each incorporated college in this State; and that the remaining copies thereof shall be deposited in the office of the secretary of State, to be distributed in such manner as the said secretary may deem expedient and proper or as the legislature may hereafter direct.

By order:

Saml. G. Andrews, *Clerk.*

In Assembly, *May 26, 1841.*

Resolved. That the assembly do concur in the above resolution.

By order:

P. B. Prindle, *Clerk.*

An act in relation to the Natural History of New York, passed May 3, 1844, by a two thirds vote.

The people of the State of New York, represented in senate and assembly, do enact as follows:

1. As fast as the several volumes of the Natural History of New York are published the governor and secretary of state are thereby authorized and required to present and transmit one copy of the same with colored plates, including a copy of the geological map of the State, to James Wadsworth, of Geneseo; one like copy to each of the governors of the several States of the Union, to be deposited by them at their discretion in some public library or literary institution within their respective States; one like copy to the Library of Congress; and 100 like copies to such foreign governments and foreign literary or scientific institutions as the governor or secretary aforesaid may select, including in their discretion such foreign governments, institutions, corporations, or persons as may have made donations to the State library.

2. The secretary of state is hereby authorized and directed to sell to such of the academies, public libraries, and literary associations in this State which are incorporated, as shall make application therefor within six months from the passage of this act, a copy of the Natural History of this State, at the price of $1 per volume, and a copy of the geological map of the State at the price of $1 per copy, and 300 copies of said volumes and map shall be reserved for that purpose.

3. The governor and secretary of state are authorized to make a distribution of the remaining copies and map of the Natural History, not otherwise appropriated or disposed of, among the several counties of this State according to the ratio or population by the last census, and transmit to the county treasurer of said counties, respectively, the number of copies to which each county shall be entitled by such distribution. The said treasurer of each of said counties shall cause the same to be sold at the price of $1 per volume, and the map for $1 per copy, and account from time to time to the secretary of State for the proceeds of the sale thereof; but he shall not sell more than one copy to any corporation, association, or individual.

4. This act shall take effect immediately.

An act concerning the Natural History of the State of New York, passed May 5, 1846

The people of the State of New York, represented in senate and assembly, do enact as follows:

1. The secretary of State is hereby authorized and directed to sell to such of the academies, public libraries, and literary associations in this State which are now incorporated, as shall have made or which shall make application therefor, a copy of the Natural History of this State, at the price of $1 per volume, and a copy of the geological map of the State at the price of $1 per copy, out of the remaining 300 copies of the said volumes and maps reserved for that purpose by the second section of the act entitled "An act in relation to the Natural History of New York," passed May 3, 1844; but no sale of the said volumes and map shall be made by the secretary of State after the expiration of one year from the passage of this act, nor a second copy to an institution which has received a copy of the said work under the provisions of chapter 254 of the laws of 1844.

2. Any person, corporation, or association other than such as purchase from the several county treasurers of this State, under the act entitled "An act in relation to the Natural History of New York," passed May 3, 1844, who shall, within one year from the passage of this act, prove to the satisfaction of

the governor and secretary of State that he, she, or they are the actual and bona fide owners of the first volumes or of any of the consecutive volumes, beginning with and including the first of the Natural History of this State, shall be entitled to purchase from said secretary the remaining volumes necessary to complete such imperfect sets of said Natural History, now published and which shall hereafter be published, together with the map accompanying the same, at the price of $1 per volume and $1 for said map; but no person who shall become such owner of the said first volume or of any of the said consecutive volumes, beginning with and including the first as aforesaid, under the fifth section of the act entitled "An act relating to the geological survey of the State," passed April 9, 1842, shall be entitled to such remaining volumes, except upon payment of $1 per volume for all such previous volumes of which he shall become the owner as aforesaid.

3. If the booksellers with whom contracts for the sale of the said work were heretofore entered into shall deliver to the secretary of state unsold copies thereof forming complete sets of the same, as far as published, the said governor and secretary are hereby authorized to sell and dispose of such complete sets with the volumes remaining to be published and the said maps, at the price of $1 per volume and $1 for said map.

4. The governor and secretary of state are hereby authorized to sell the copyright of said work in separate portions or otherwise as soon as the remaining volumes thereof shall be published.

5. It shall be the duty of the several county treasurers of this State, in selling the volumes of the Natural History of New York, in pursuance of the act entitled "An act in relation to the Natural History of New York," passed May 3, 1844, to sell and deliver the volumes of said Natural History, first, to any such person or association as shall within six months after such treasurer shall have received hereafter the several volumes of said Natural History, prove to the satisfaction of said treasurer, that he, she, or they are the present bona fide owners of the preceding volumes of said Natural History, sold under the said act of May 3, 1844, by the treasurer of the same county to whom application shall be made.

6. This act shall take effect immediately.

An act in relation to the Natural History of the State of New York, passed May 5, 1847.

The people of the State of New York, represented in senate and assembly, do enact as follows:

1. The provisions of the first and second sections of the act entitled "An act concerning the Natural History of the State of New York," passed May 5, 1846, are hereby continued, and shall be in force for the term of one year from the passage of this act; and the secretary of state is hereby authorized and directed to sell to such of the institutions named in the first section of the above-mentioned act which now are or hereafter may be incorporated during the continuance of this act, copies of the Natural History of this State, upon the conditions and subject to the restrictions therein contained.

2. This act shall take effect immediately.

An act in relation to the Natural History of the State of New York, passed April 16, 1852.

The people of the State of New York, represented in senate and assembly, do enact as follows:

1. The provisions of the first and second sections of the act entitled "An act concerning the Natural History of the State of New York," passed May 5,

1846 (see p. 35), are hereby continued, and shall be in force for the term of two years from the passage of this act; and the secretary of state is hereby authorized and directed to sell to such of the institutions named in the first section of the above-mentioned act which now are incorporated during the continuance of this act, copies of the Natural History of this State upon the conditions and subject to the restrictions therein contained.

2. This act shall take effect immediately.

An act in relation to the Colonial History of the State and the Natural History thereof, passed April 16, 1850, three-fifths being present.

The people of the State of New York, represented in senate and assembly, do enact as follows:

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SEC. 3. The volumes of the Natural History of the State, hereafter to be published, shall, when sold, be disposed of at not less than $5 each, instead of the price now fixed by law: *Provided always*, That all colleges, academies, scientific institutions, and library associations, which own the volumes already published, or the greater part of them, shall have the right to complete their sets on the terms heretofore established for that purpose.

SEC. 4. All acts or parts of acts inconsistent with the provisions of this act are hereby repealed.

SEC. 5. This act shall take effect immediately.

Early in 1850 an act was passed transferring the control of the survey and State cabinet into the care of the secretary of state and the board of regents of the State university. The following is the text of this act:

An act to provide for the completion of the geological survey of the State, passed April 10, 1850.

The people of the State of New York, represented in senate and assembly, do enact as follows:

1. The secretary of state is hereby authorized and directed to take charge of all the matters pertaining to the prosecution and publication of the geological survey of the State.

2. It shall be the duty of the secretary of state and the secretary of the regents of the university to examine into and report to the next legislature upon all claims that may be made upon the State for work done on account of the geological survey, and upon all contracts that may exist between the State and individuals for work yet to be done on account of the survey.

3. It shall be the duty of the secretary of state and of the secretary of the regents of the university to report to the next legislature a plan for the final completion of said survey, and to submit the estimates of the cost of such completion.

4. This act shall take effect immediately.

Shortly after the passage of this act the secretary of the board removed Doctor Emmons from the curatorship and deprived both of the geologists of their quarters in the old State house. Expelled from the State house, writes Stevenson,[1] Hall at once erected a build-

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[1] Bull. Geol. Soc. of America, vol. 10, 1898, p. 428.

JAMES HALL

STATE GEOLOGIST OF NEW YORK, 1843-98;
IOWA, 1855-58; WISCONSIN 1860-62.

ing adjoining his residence, where his work was carried on until 1852, when he removed to a larger house. In 1857 he erected a very commodious brick building in which the work was carried on until his death.

By the act of 1850 the legislators cut off all appropriations for current expenses and salaries, according to J. J. Stevenson, though for some reason, which is not apparent, the contract for engraving illustrations for the reports was carried on and small appropriations made for drawings. Although the State thus signified its intention to abandon the work, Hall refused to give up.[1] Confident that it would some time be resumed, he retained his assistants for a time and continued the collecting and drawing until 1855 at his own expense. About that time, despairing of any assistance from the State, he accepted a proposition made years before by Sir William Logan that he become paleontologist of the Canadian survey. This came to the ears of the Hon. Elias Leavenworth, then recently elected secretary of state, who realized that to abandon the work in its incomplete condition would be discreditable to the State. He urged Professor Hall to delay, and called a meeting, which was attended by J. D. Dana, Louis Agassiz, W. E. Logan, Mr. Blatchford, L. C. Beck, and others, to consider the matter. At this conference a plan for continuing the work was prepared, Professor Hall consenting to remain in case the legislature confirmed the agreement. Through the influence of Mr. Leavenworth such agreement was reached, and Professor Hall remained to carry on the work for 43 years longer.

With the apparent purpose of showing the legislative committee the value placed upon his work by others than those immediately interested, Hall in 1855 submitted to Sir William Logan, of the Canadian survey, a series of questions bearing upon the subject. These, together with their answers, are given below:

1. Have you been acquainted with the progress of the paleontology of New York, and for how long a time?

2. What is your opinion of the value and usefulness of the work to geological science and to the advancement of a knowledge of the geological structure of the United States?

3. Has this work, as far as published, been of use to you in your geological explorations in Canada?

4. At the commencement of the investigations of the paleontology of New York, the collections of the geological survey contained some 50 or 60 species

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[1] In the report of the assembly committee (Assembly Doc. No. 124, Apr. 1, 1851) appointed to take charge of the publications of the geological reports, April, 1851, an estimate is given by Professor Hall of three additional volumes on paleontology. These it is thought would cost $16,000 a volume, exclusive of salaries and printing. They recommended that the work be completed in accordance with these estimates, and that for the purpose of entering this the sum of $2,500 be paid Professor Hall on the presentation of the manuscript letterpress of each volume ready for the printer, together with the fossils described therein. Nothing seems to have come from this.

of Lower Silurian fossils. Do you think it would have been judicious or desirable to publish a work upon the paleontology of the State of New York, in which only this number of Lower Silurian fossils should have been given?

5. There were less than 50 species in the same collections from Medina sandstone, Clinton group and Niagara group, being in each instance less than one-sixth of the number published from these formations respectively in the first and second volumes of the paleontology of New York. The same condition also existed in relation to the fossils of the lower Helderberg period and Oriskany sandstone, which are comprised in the third volume, now in progress. What, in your opinion, would have been the estimation and the present opinion of that portion of the public capable of judging of a work entitled the "Paleontology of New York" which would have given some 50 or 60 species from each of the periods here mentioned; and would it have been creditable to either the author or to the State under whose patronage the work is published?

6. In the volumes of this work already published a few species of fossils are introduced from adjoining States into which the same geological formations extended, and where they had been studied by the author with a view to bring them into harmony with the system and nomenclature adopted in New York. What is your opinion of the propriety and importance of such a course, and how does it affect the value of these publications?

7. Do you or do you not consider that New York has by this publication enhanced or sustained her claim to the nomenclature adopted in her geological reports: and what would probably have been the result in reference to this nomeclature, had a paleontology been published in that work, and without any reference to the extension of the same formations, into other States, or their identification by fossil remains?

8. Have you any means of knowing the opinion of other geologists or naturalists in this country or in Europe in reference to the value and importance of this work to American geology?

9. It has been complained of that too many illustrations of each species are given in the plates of this work. Have you had occasion to use the volumes for the comparison of your species, and if so, have you often found superfluous figures of species?

10. Have you had an opportunity of examining the collections which have been made during the progress of the work on the paleontology of New York, and what is your opinion of the same?

11. With your knowledge and experience of the labor and expense of collecting specimens for such a work, what would you estimate as the cost of making the necessary collections for each volume of those published, or upon what footing would you consider it necessary to organize such a department, and what time would be required with that organization to make the collections from the entire areas occupied by the different formations embraced therein; and to complete a volume of the work in the manner already done?

12. With all the assistance I can employ in making collections, and with the necessary field examinations to be made by myself, the superintendence of drawings, engravings, comparisons of species with others described in similar works, writing descriptions, and superintending the printing of work. I have estimated that four years is but a reasonable time to be allowed for each volume. Will you express an opinion on this point?

13. The proposition made by the commissioners having direction of the department is that I shall receive $2,500 when a volume is completed, and this

sum shall include the fossils described; will you give me your opinion of this proposition, and whether it is such a one as any man competent to do this work would accept as the only remuneration for his services.

14. I have claimed that the labor and expense of making a proper collection for the preparation of the work on the paleontology is fully equal to, or even greater, than that of making the original geological surveys and collections in the same districts of country in the State of New York. What is your opinion in regard to this point?

15. I shall be further under obligations to you if you will offer any suggestions as to the proper mode of organizing this department; and also for any facts or arguments that might have weight with the authorities in New York having charge of this work, which would show the necessity and importance of carrying out to a proper degree of perfection in the collections the results of the survey of New York. In this connection I would consider a few words upon the plan and ultimate objects of your geological museum of great importance.

March 17, 1855.

To this the following reply was received:

GEOLOGICAL SURVEY OFFICE,
Montreal, March 17, 1855.

To Prof. JAMES HALL,
Paleontologist of New York.

DEAR SIR: In reply to the questions you have proposed to me on the subject of the publications connected with the paleontology of New York I beg to send you what follows:

1. I have been acquainted with the progress of the work upon the paleontology of New York ever since I came to America in 1843.

2. The value and usefulness of the work to geological science can not be too highly estimated. It constitutes the only safe guide that I am acquainted with to enable us to understand with accuracy, as far as it goes, the true sequence of the rocks of North America and thus to follow out the physical structure of the continent.

3. After undertaking the geological survey of Canada I availed myself of the first opportunity that offered, which was, I believe, in the beginning of 1866, to pay a visit to Albany for the purpose of making myself acquainted, as far as I could, with what was known of the paleontology of New York. The first volume of your work was not then published, but by your kindness I was put in advance of the public and enabled to complete a tabular list comprehending every fossil known. Many of these were not then specifically named; and in addition I was permitted to make manuscript copies of such drawings and plates as you had, representing the forms. Without this I should have been under the necessity of establishing by very laborious comparison a set of paleontological rules for myself. But with it I was at once enabled to enter upon a determination in detail of the sequence of such Canadian rocks as came under my observation. This was, however, chiefly in regard to the Lower Silurian series. But even in regard to this I found when your first volume came before the public in 1866 that you had added greatly to the number of species, and this volume has ever since been a most valuable guide. Bulky as it is, I have frequently considered it expedient to take it to the field with me when examining Lower Silurian rocks in distant localities. In the list I obtained from you the number of species in the higher rocks were so much fewer that until the second volume came out the want of equal detail from undisturbed locality rendered the determination of the various members of the Upper Silu-

rian and Devonian Series of Gaspé, where the rocks are much disturbed, so very difficult a problem that I considered it would be a saving of time to wait until that volume should appear before venturing on the task; and your late examination of our collection of Gaspé, fossils will have shown you how liable I should have been to commit errors; some of the results you have obtained indicating the propriety of a reexamination of parts to ascertain whether small local troughs of upper rocks are not placed on lower ones, when mere mineral evidence would lead to no suspicion of the fact. It will be readily seen from this of what indispensable use your paleontology is in the examination of Canada.

4. It would have been a misfortune to the geological world if the paleontology of New York had stopped at 50 Lower Silurian species, but possibly Canada in that case, with a larger number of unpublished species in her collection, might the sooner have been tempted to figure and publish them.

5. As long as the 50 species for each formation were considered to be all or nearly all that were to be found after diligent search, although the paucity of species might have surprised naturalists, and have led to wrong conclusions in respect to the life of the periods, when it became ultimately known that this was only one-sixth of the whole, it could not fail to be considered that in giving it as the result of a national work, the State had been lamentably deficent.

6. The more extended the comparison, the more valuable the result; and in traveling out of the State of New York in following the geographical distribution of the formations which compose its subsoil, you have only the more clearly shown what I have frequently heard Sir Charles Lyell remark, that the complete geology of New York is the key to that of all North America.

7. Until some other State in the Union or some other country in North America shall have published a greater number than New York of the fossil species which characterize the formations common to both, the nomenclature of New York will remain perfectly secure. Through the volumes which have been published on the paleontology of New York the nomenclature of her rocks has become classical in Europe as belonging to North America. If New York had given but one-sixth of the species now published, it seems to me not improbable that Canada would ultimately have a fair chance (considering the unity of design with which the investigation of the geology is carried on) of giving a nomenclature to the rocks of North America. In regard to those formations of New York of which the fossils are not yet published, we shall, if the probable recommendations of the present geological committee of our legislature assembly are carried out, very possibly be treading on your heels. It would only be the personal consideration due to one who had done so much as you have for the paleontology of North America and so materially abridged our labor by your own that would restrain us from interfering.

8. In 1850 I carried to England upwards of 50 boxes of Canadian fossils, each box requiring two men to lift it, with a view of making, with the aid of the paleontologists of the geological survey of the United Kingdom, a comparison between American and European types. A partial examination of the collection was made by Mr. Salter. In the course of it many English and continental European authorities in paleontology were referred to, but to ascertain whether the fossils were new to America the only reference it was considered necessary to make was to your publications. This, of course, regarded Lower Silurian species, your second volume not being then published, but you can judge from this the estimation in which the first volume is held in England as an American authority.

9. It appears to me it can be only those who have not the task of comparison imposed on them that can complain of too much illustration. In working out my fossils I have often regretted that you do not always give five distinct views of each bivalve shell to make it understood in all its aspects. In regard to all shells it is of great importance when you light upon a fertile habitat of some one species to give the gradations of form that constitute varieties, often showing such diversities in the extremes as without the gradations might be taken for different species. It is important also to give the gradations from young to old.

10. On a very recent occasion I had an opportunity of examining the collection made by you for the purpose of enabl'ng you to bring out in the best manner the paleontology of New York. In my opinion it is a most valuable and magnificent one.

To the remaining questions I shall endeavor to reply on a future occasion.

I am, dear sir,
Very truly, yours,
(Signed) W. E. Logan.

Geological Survey Office,
Montreal, March 20, 1855.

To Prof. Js. Hall,
Paleontologist of New York.

Dear Sir: In addition to the replies I sent you yesterday I have further to state in answer to your questions 11, 12, 13, 14, and 15, that it must unavoidably require a very considerable time to make such a collection of material as you exhibited to me at Albany. Either through personal observation or the work of persons in whose skill and fidelity you can place implicit reliance, it is necessary to ascertain the exact locality of every specimen, not merely geographically but geologically, and to know how each individual bed of rock from which a fossil is derived is related to all the rest. Where individual species are largely developed it is requisite to ascertain what conditions in the deposit accompany so fruitful a habitat, and a very large number of individuals from such a locality should be taken in order to determine what is normal and what abnormal in the form. The variations of the same species in different localities must be attended to and the differences in the deposits which accompany these variations. When exposures of great thickness in any formation are met with, each bed should be observed separately, and all the fossils from it should be kept and registered separately until a proper comparison of the contents of the bed is made with those of all the rest, and all the evidence made available for a history of the accumulation of the deposits and of the events affecting the life of the period. When apparent defalcations occur in the sequence especial care must be exercised to ascertain whether formations supposed to be absent may not be represented by some thin layer characterized by its fossils. Much confusion and dispute has occasionally arisen from the foss'ls of a bed of this description having been mingled with those of the deposits above or below. To make such a collection as you have, and to attend in so doing to all such details as are here enumerated, over a great area, more time, labor and expense would be required than were absorbed in the original geological exploration of New York.

It appears to me that four years is a very moderate time for the production of such an original and valuable volume as each of yours on the paleontology of New York and $2.500 a wholly inadequate remuneration for the work of a person capable of producing it, in such a manner as will be creditable to himself and to the State. In the estimate which I have given to our geological committee for the publication of fossils, I have stated that for a decade such as those published by the government geological survey of the United Kingdom, comprehending drawings and engravings of 10 octavo plates, with letterpress descriptions and the printing of 2,000 copies, one decade to be put forth in a year, the sum of £500 currency or $2,000 would be required. But this of course excludes the collection of the fossils, which would be a labor to be paid for separately. At present the collection of the fossils is part of the work performed by the officers of the survey and great attention is devoted to making the collection as copious as possible, in order that the provincial museum may contain as full evidence as can be obtained to prove the true sequence of the formations and of the useful materials with which they are associated.

The arrangements of the museum are intended to be an imitation of those of the museum of practical geology in London connected with the British Government survey. The objects held in view are the science of geology and its application to the useful purpose of life. In the ordinary arrangements of minerals in museums they are exhibited as they are related to one another in crystalline form, chemical composition or some other marks of individuality by which they can be grouped. Such an arrangement teaches mineralogy. They may be shown as they are grouped together in the veins or beds which contain them, with the character and attitude of the beds and of the veins which intersect them. If to these particulars be added the sequence of the strata and the fossils which mark them, the arrangement would illustrate the geological relations of minerals. Another mode of displaying them might comprehend the useful purpose to which they can be devoted and it is in this arrangement perhaps that a national collection of mineral substances can be made most available for the instruction of the public.

Including this branch of the subject the provincial museum is intended to display by specimens the mineral and mechanical character of the rocks of which the country is composed; by geological maps and sections, their geographical distribution and their attitude; by fossils, the marks and brands which distinguish them in their sequence; and by examples, the useful purposes to which their contents can be applied. In a new country just beginning to ascertain its possession of useful minerals, one of the most difficult things is to introduce the skill required to make them available. Descriptions of them and their applications may be written and printed, but it is not easy to get the descriptions read; but it requires little tuition to comprehend the objects of industrial art when they are addressed to the eye, and imitative skill is more easily excited by the sight of such objects than by written descriptions, even where they are understood. In a collection of such objects many persons to whom the knowledge would in no other way come, may recognize many substances which they have in abundance at their own door, but of which they know not the use. The examples which show this use may prompt attempts to make them available; and the collection thus becoming a school of mineral arts might be the means of exciting native industry.

I am, dear sir,

Very truly, yours,

(Signed) W. E. LOGAN.

Benefits.—According to Hall, the few years' field work of the geological survey of New York resulted in harmonizing the conflicting views before entertained regarding the relations of the eastern and western parts of the State; they had traced the boundaries of the successive geological formations, had shown the extent and limits of the iron-bearing strata, and had rectified the erroneous views which had been held until sometime after the commencement of the survey, regarding the boundaries and distribution of the salt-bearing formations of the State. They had also shown the extent of the granitic formations and their associated mineral products, the thickness and extent of all the limestone, sandstone, and shale formations of the State, and had definitely settled the relations of the rocks of New York to the coal measures of Pennsylvania and the geological formations of the Western States.

Their labors had in a great degree quieted the feverish anxiety regarding the discovery of coal within the limits of New York, for which frequent explorations had been made in the black slates of Hudson River valley and elsewhere, involving the expenditure of much money[1] and loss of time. During these years the New York geologists had accumulated a vast amount of material and of facts regarding the geological formations within the State, proving conclusively that they could not be paralleled with any of the described and well-determined formations of Europe. The Silurian system of Murchison, although covering a portion of similar ground, was not broad enough to meet the requirements of the geology of New York. Thus failing to find the means of comparison and identification, the term "New York system" was proposed, to embrace the sedimentary formations from the Potsdam sandstone to the base of the Carboniferous system; or, as the formations were developed in New York and southerly into Pennsylvania, the upward extension of this system reached the base of the coal measures. The term, then, was made to include the formations ordinarily embraced in the names of Cambrian, Silurian, and Devonian of England and the continent of Europe. The geological series of New York was found to be so complete that the succession left no lines or breaks for the establishment of systems, the whole being but a single system, and, it is added, had the older rocks of the globe been first studied in New York no such terms or subdivisions would ever have found their way into geological nomenclature. There being no possibility of identifying the individual rocks and groups of strata with those of Europe as they had been described, the New York geologists felt compelled to give names to the different members of the series, and since the sandstones, limestones, slates, and shales were so similar in different and successive groups, it was impossible to give descriptive names which would discriminate one from the other. Local names, as Potsdam sandstone, Trenton limestone, Niagara limestone, etc., were therefore adopted.

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[1] During the 50 years preceding 1840 more than a quarter of a million dollars had been thus expended in the Hudson Valley alone.

This method or system of nomenclature left no probability of mistake or confusion which might arise from a different appreciation of descriptive terms, since the typical locality as indicated by the name always remained for study and reference. The progress of geological science in the country had been under great indebtedness to this system of nomenclature.

Referring to the cost of the survey, Hall says:

> The value of the results is sometimes estimated by a similar standard—that is, by dollars—but the people of the State of New York might with equal propriety measure the value of the common-school system by the commercial value of their schoolhouses and grounds. The absurdity would be equally as great in the one as in the other. Like the system of public education, the results of the geological survey have penetrated into every school district and into every corner of the State, and these results are not to be measured by the figures representing dollars, but by the increased intelligence of the people and the proud satisfaction that we have been able to lay broad and deep foundations of geological science in the soil of a people whose motto is "Excelsior."[1]

State museum.—In his report for 1836 relating to the establishment of the survey, the secretary of state called attention to a petition by the Albany Institute in 1834 asking State aid in forming "a grand and comprehensive collection of the natural productions of the State of New York to exhibit at one view and under one roof its animal and mineral wealth." He did not, however, recommend that such an arrangement be entered into with the institute, but rather that rooms on the third floor of the capitol building be prepared for the exhibition of the collections. This arrangement, however, proved inadequate, and in his message to the legislature, dated February 27, 1839, Governor Seward wrote as follows:

> It ought to be known to the legislature that the collections of specimens will far exceed in number and value the expectations indulged at the time of the passage of the act and can not be profitably nor conveniently deposited in the State Library or in any apartments in the capitol which can be appropriated for that purpose. The whole collection will form a museum of the highest scientific interest. Unless suitable arrangements are made for its preservation and exhibition the benefits of the survey will be in a great measure lost.

Later (in 1840), in response to a memorial from the geologists urging the importance of providing suitable rooms or a separate building for the collections made during the survey, Governor Seward recommended that the old state hall be thus utilized. This was provided for by the act of April 12, 1842.

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[1] Popular Science Monthly, vol. 22, 1882–83.

In the reports of the survey, dated January, 1842, it is stated that eight suites of specimens had been collected, the one which was designed for preservation by the State comprising some 20,000 specimens.

By the act of 1843 (see p. 332) the governor was authorized to continue the services of one or both of the geologists who were living in Albany, Ebenezer Emmons and James Hall, for the purpose of completing and arranging the collections of specimens in the old state hall, and in accordance with this authority, Doctor Emmons was for a time charged with this arrangement. The building referred to as the old state hall followed on the same site the original building erected for State offices in 1797 during the governorship of John Jay, and which was made over in 1855 into the geological hall.

By virtue of an act passed May 10, 1845, and constituting chapter 179 of the laws of that year, the regents of the university, to whom was committed the care of the "State cabinet of natural history," were authorized to make a suitable provision for the safe-keeping of the collections and a small appropriation ($800 annually) was made to defray the expenses of custodianship. Under the authority thus vested in the regents of the university, annual reports were begun upon the condition of the State cabinet of natural history, the first of these being dated April 11, 1848. The administration of the affairs of the natural history collections was carried on as an independent charge of the regents for many years, during which period the scientific investigations, which were being prosecuted by Prof. James Hall in paleontology, Dr. Ebenezer Emmons in agriculture and geology, and by Dr. Asa Fitch in entomology, were entirely independent of the organization of the State cabinet.

The custodianship of the collections was first assigned to John Washington Taylor, who was succeeded by John Gebhard, jr., and he, in 1859, was followed by Col. Ezekiel Jewett. After seven years of service Colonel Jewett resigned, and in 1866 Professor Hall was made curator of the State cabinet, as noted later.

Up to this time the development of the museum along truly scientific lines had been but slight. The collections had failed to exemplify the progress of scientific investigations in the State, and although it was supposed that they would continue to be the depository of the scientific work still in progress, this did not altogether prove to be the case. Provision was made for their development and increase only by the most meager annual appropriations and the condition aroused the solicitude both of the board of regents and of the friends of science throughout the State.

Following this the regents of the university addressed a letter to numerous scientific men throughout the country asking suggestions as to the best mode of putting in force the objects of the legislature as expressed in the resolution referred to. The following is a literal transcription of this letter:

OFFICE OF THE REGENTS OF THE
UNIVERSITY OF THE STATE OF NEW YORK,
Albany, June 1, 1865.

SIR: The senate and the assembly of the State of New York, on the 24th of April last, each adopted the following resolution:

Whereas the collections in geology, mineralogy, and other departments of natural history, made by the geological survey of the State, were committed to the charge of the regents of the university by act of the legislature in 1845, and the reports published before and since that period as the results of the survey, have conferred great credit upon the State of New York, both at home and abroad, and the nomenclature proposed by her geologists has been adopted by other States, and in the geological survey of Canada, and is well known, appreciated, and recognized by the scientific men of Europe: and

Whereas great progress has been made since that period in geological investigations, both here and abroad, and it is due to science, as well as a suitable recognition of the great credit given to the State of New York, that her preeminence be sustained by keeping up the character and authenticity of her collections as a museum of practical and scientific geology: Therefore be it

Resolved, That the regents of the university report to the legislature at its next session what means may be necessary, together with a plan, for placing the State cabinet of natural history in the condition required by the present state of science, and to maintain it in full efficiency as a museum of scientific and practical geology and comparative zoology; and whether the establishment of a system of free lectures in connection with the cabinet is desirable, and if so, on what general plan the same should be founded.

The regents of the university have committed the duty of preparing their answer to this resolution to their standing committee on the State cabinet of natural history.

In the discharge of this duty the committee desire to avail themselves of the aid of those whose special studies relate to the subject of natural history in any of its branches and of all who are interested in the increase and spread of knowledge. They trust that the general scientific and economic interests to be subserved by the action contemplated in the resolution will induce cordial cooperation with them on the part of those to whom this circular letter is addressed.

They will be obliged to you for the expression of your views and suggestions upon any or all of the following topics, or upon any branch of them:

1st. Plans for placing the State cabinet of natural history in the condition required by the present state of science and for maintaining it in full efficiency as a museum of scientific and practical geology and comparative zoology.

2d. The proper organization of a scientific staff to carry out such plans and estimates of the proper compensation thereof and of the other expenditures, temporary or permanent, requisite to the attainment of the ends in view.

3d. The desirableness of a system of free lectures in connection with the cabinet, and if deemed desirable, a general plan for founding such a system of lectures.

Answers are requested as early at least as the 1st of September next, to be addressed to the undersigned at Albany.

I have the honor to be, sir, your obedient servant,

S. B. WOOLWORTH,
Secretary of the Regents, on behalf of the Committee.

Replies to this were received from J. D. Dana, W. E. Logan, T. Sterry Hunt, Alexander Winchell, Oren Root, Alexander Agassiz, F. B. Hough, A. A. Gould, and J. J. Thomas.[1] As a result, the regents, in the annual report for this year, submitted a "plan for placing the State cabinet of natural history in the condition required by the present state of science; to maintain it in full efficiency as a museum of scientific and practical geology and comparative zoology," communicating therewith the replies to their circular letter from the various scientific men of eminence, noted above.

In 1866, again, in accordance with the plan and resolutions, James Hall was appointed by the regents to take the position of curator of the State cabinet with a view to carrying out the recommendations embraced in their report. During 1867, 1868, and 1869 fruitless efforts were made at each session of the legislature to secure the passage of a suitable law, but action was not formally taken until 1870, when a law was passed organizing the cabinet as the "State Museum of Natural History," and appropriating $10,000 annually to provide for the salary of the director and his assistants and for the increase and preservation of the collections. At this time also the additional sum of $1,500 was appropriated for the annual salary of the botanist.

Following is the text of the act:

An act in relation to the State Cabinet of Natural History, passed May 2, 1870, three-fifths being present.

The people of the State of New York, represented in senate and assembly, do enact as follows:

SECTION 1. The State cabinet of natural history is hereby established as a museum of scientific and practical geology and general natural history, at the capital of the State, under the care and custody of the regents of the university, to be known hereafter as "The New York State Museum of Natural History."

2. The museum shall be organized in accordance with the plan recommended to the legislature by the board of regents in their report of 1866, and the present curator shall act as director of the museum and shall supervise and direct all its scientific and practical operations, and he shall appoint such assistants or curators of departments as may be required for the accomplishment of said plan, with the concurrence of the chancellor of the board of regents or the committee of the same having charge of the museum.

3. It shall be the duty of the director of the museum and the chancellor of the board of regents to organize a plan and make the necessary arrangements to establish an annual course of free scientific lectures in connection with the museum as soon as practicable and within two years from the passage of this act.

4. For the salary of the director as established in the appropriation bill of 1870, for three assistants as now employed by him, and for the increase and preservation of the collection, the sum of $10,000 annually shall be, and is hereby, appropriated, and all expenditures for compensation of assistants or for

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[1] Printed in full in the Nineteenth Annual Report of the State Natural History Survey, 1866.

the increase and preservation of the collections shall be made by the director with the approval of the chancellor of the board of regents.

5. The botanical department as now organized shall be continued, as originally contemplated, for three years from the end of the present year.

6. This act shall take effect upon its final passage.

This was supplemented the following year as below:

An act to amend an act entitled "An act in relation to the State Cabinet of Natural History," passed May 2, 1870; passed April 25, 1871, three-fifths being present.

The people of the State of New York, represented in senate and assembly, do enact as follows:

SECTION 1. The assistants and curators of departments provided for by the second section of the act entitled "An act in relation to the State Cabinet of Natural History," passed May 2, 1870, shall be appointed by the director of the State Museum of Natural History, with the concurrence of the board of regents of the university.

2. The annual course of free scientific lectures authorized by the third section of said act shall be organized under the direction of the board of regents and the director of the State museum.

3. The moneys appropriated by the fourth section of the act above named shall be expended by the director of the State Museum of Natural History, with the approval of the board of regents of the university.

4. This act shall take effect immediately.

For James Hall, as State geologist, for the use of working rooms, fuel, lights, and other expenses incurred, for the preparation of the paleontology of New York, and for the distribution of duplicate fossils, as provided by law, to the 1st of January, 1871, there was appropriated $1,000.

The following letter illustrates pretty clearly the disadvantages under which Hall had been laboring and the necessity for such action:

ALBANY, *March 27, 1871.*

HON. DE WITT C. LITTLEJOHN.

DEAR SIR: I send you with my sincere regards volume 4, Paleontology of New York, and I hope I may have the pleasure of sending you the succeeding volumes, though I learn that the committee of ways and means at its last session struck out the appropriation for the original drawings for the work.

I have yet to come before the committee of ways and means to ask for a sum to defray in part the expense of working rooms and other expenses while engaged in this work and I bespeak your patience and forbearance. For all my own labor upon this work in superintending drawings and engravings I have received nothing since 1866. Three separate laws have been passed requiring that I arrange and label a collection of duplicate fossils for several institutions. There are no working rooms at the State museum adapted for this work and I have been compelled to furnish them. In order to have greater conveniences I have begun and nearly completed the fitting up of the principal part of an entire building of 30 by 45 feet, two-thirds of the basement and all of the principal and part of the second story being devoted to this work. Between November of last year and the month of May, 1871, I shall have expended at least $1,500 to prepare working rooms, drawers, etc., required for this work.

With these additional duties, as also that imposed by a resolution of the legislature and commissioners of the land office requiring me to be on duty two evenings in the week, I shall receive no extra compensation, and I hope the committee may feel disposed to grant a part of the money I have found it necessary to expend in the manner specified.

I am very sincerely and respectfully, yours.

(Signed) JAMES HALL.

In 1883, by legislative enactment, the work of the State Museum of Natural History, of the State paleontologist, of the State botanist, and of the State entomologist, was brought together under the charge of the regents of the university, each becoming a department of the museum. The following is the text of this act:

An act to regulate the State Museum of Natural History and the publication of the paleontology of the State, passed May 4, 1883, three-fifths being present.

The people of the State of New York, represented in senate and assembly, do enact as follows:

SECTION 1. For the purpose of providing sufficient and fireproof accommodations for the collections of natural history belonging to the State the regents of the university, as trustees of the State Museum of Natural History, are hereby directed, in pursuance of the concurrent resolution of the legislature, passed on the 24th day of March, 1881, to occupy for the purposes of said museum the several rooms of the State hall as they may be vacated by the present occupants, and said trustees are hereby directed to fit up and prepare said rooms in a suitable manner and to remove thither and arrange in order for exhibition, as soon as may be, the collections of said museum. Said trustees shall also make provision for and remove to said State hall, to be a part of said museum, all the fossils, minerals, and other property of the State now in the charge of the State geologist, in pursuance of the provisions of chapter 270 of the laws of 1882; and the sum of $20,000, or so much thereof as may be necessary, is hereby appropriated for the expenses of fitting up and removal as provided in this section, to be paid on vouchers approved by said trustees.

SEC. 2. The scientific staff of the museum, to be appointed by said trustees, shall consist of a director, who may also be State geologist, and whose compensation shall be the same as now fixed by law, and of three assistants, together with such special assistants as may be necessary, whose compensation shall be fixed from time to time by said trustees, together with the State geologist and State entomologist and botanist, as these officers are now defined and provided for by law; and all the collections made by the members of said staff during their terms of service shall belong to and form a part of the collections of the museum; and the trustees of said museum shall be authorized to publish each year the scientific contributions of said staff and such other original scientific contributions as they may deem expedient, which publication shall be in lieu of the reports now required by law from the State geologist and State entomologist, and of the scientific papers communicated each year to the legislature, along with the annexed report of said trustees; and it shall be the duty of said trustees to distribute from the duplicate specimens of the museum to institutions of learning such collections as may be available and suitable for that purpose, as directed by a concurrent resolution of the legislature, passed on the 14th day of March, 1881, and to provide facilities in the museum for the study of its collections, and by means of printed handbooks describing said collections, and in such other ways as may be practicable to make said museum a means of instruction to the citizens of the State. In order to provide for the expense of printing the aforesaid scientific publications, and in order to increase the usefulness and efficiency of said museum as aforesaid, the annual appropriation to be made for its maintenance shall be $15,000, to be paid on vouchers approved by said trustees.

Sec. 3. The trustees of the State Museum of Natural History are hereby appointed to supervise the completion of the publication of the paleontology of the State, to contract for the preparation and printing thereof, and to audit and certify to the expenditures therefor; and it is hereby provided that one volume of said paleontology shall be published within one year from the execution of the contract for its preparation, that a second volume shall be published within two years, and that the entire work shall not extend beyond five bound volumes in addition to those already issued, all of which shall be published within five years from the passage of this act, and shall comprise the following subjects; that is to say, the Lamellibranchiata (bivalve shells) to be bound in two volumes; the Bryozoans (fossil corals) to be bound in two volumes; the Brachiopoda (lamp shells) to be bound in one volume; and the Crustacea, etc. (crabs, etc.) to be bound in one volume; and the sum of $15,000 shall be appropriated annually for five years for the purposes of this section, payable on vouchers certified by said trustees; which sum of $15,000 or so much thereof as may be necessary, is hereby appropriated, out of any money in the treasury not otherwise appropriated, for the purpose of said publication for the current year.

Sec. 4. The volumes of the natural history hereafter to be published and the copies still remaining of the volumes already published shall be in the charge of the trustees of said museum, who shall distribute and sell the same in accordance with the provisions of law now in force for such distribution and sale, and the proceeds of such sale said trustees shall use for the purpose of forming a suitable library for said museum, and they shall have authority to make exchanges with such portion of the volumes of said work as are not required for distribution or sale and to receive donations and deposits of books and specimens on such terms as they shall deem advantageous for said museum.

Under this provision a scientific staff was created, subject to appointment by the trustees, to consist of a director, "who may also be State geologist," and "of three assistants, together with such special assistants as may be necessary, whose compensation shall be fixed from time to time by the said trustees, together with the State geologist, State entomologist, and botanist as these officers are now defined and provided for by law."

With this incorporation of the departments into the general organization of the State museum, the scientific staff became in a certain definite sense subsidiary or contributory to the general functions of the museum as a depository of scientific collections.

The same law recognized the fact that the geological hall was insufficient both in capacity and in construction for the accommodation of the greatly increased collections of the State museum and the scientific work of its departments, and authorized the regents of the university to take possession of the present State hall, as its rooms should be vacated by the State officers who were to be accommodated in the new capitol. In pursuance of this provision several of the rooms in the State hall were in 1886 occupied by the staff of the State geologist and paleontologist and by the State botanist, and the more valuable and typical portions of the paleontologic and botanic collections removed thereto. It subsequently proved impracticable to acquire full possession of the State hall on account of the reluctance of its occupants to remove to other quarters, but the office of the State paleontologist and the larger part of the collections in paleontology have been in this building from that date to the present.

The following letter from Hall to Governor Cleveland is self-explanatory:

ALBANY, *May 20, 1884.*

His Excellency GROVER CLEVELAND,
Governor of New York.

SIR: I beg leave to offer you the explanation I had proposed to give when I called upon your excellency in regard to the appropriation of $2.500 for the services of the State geologist, the expenses of working rooms, etc., and to do this it is necessary to state the original cause of this agreement.

In 1855 I was charged with the duty of collecting fossils to be used in the preparation of the paleontology of the State. At that time and previously the wing of the museum building (the old State hall) was and had been in use for working rooms and laboratory. This building was demolished and the present one erected in 1856 and 1857. In the allotment of rooms in the new building the entire wing was awarded to the agricultural society, leaving no rooms for the geological work. After repeated applications to the proper officers I was informed that there were no rooms to be had in the museum or any other public building and that it would be necessary to procure outside quarters.

The collections, packed in boxes and stored in a cellar, could not be used and were of no value for the object intended. In 1857 I began the erection of a brick building on my own ground, and in the following year completed and fitted up the same with drawers, library, and other facilities for carrying on the work which I was required to do. As the collections accumulated more room was required, and later I erected another building[1] for their accommodation.

During subsequent years some appropriations were made to cover the necessary expense, but these were irregular and uncertain. In 1871 I applied for the use and expenses of these buildings and for my own services, furnishing a memorandum of the several sources of expenditure. The subject was referred to the lieutenant governor, comptroller, and secretary of state, who recommended an appropriation of $2,500 as a proper compensation for the duties and expenses therein specified.

A copy of this memorandum with the recommendation of the officers is herewith appended.

The appropriation of $2,500 has been annually made since that time. In the meantime the collections have continued to accumulate, more conveniences for working rooms and for the arrangement of the specimens have been demanded and supplied, and the expenses have constantly increased. At the same time increased duties have been imposed upon the State geologist, which he has endeavored to perform to the best of his ability.

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[1] The brick building consists of a main part 30 by 42 feet and a wing for working room and library of 28 by 30 feet. The second building is of wood 30 by 45 feet. The cost of erection and fitting up these buildings has been more than $10,000, while my private library necessary for use in this work is worth $6,000.

It has been provided in the item of appropriation that whenever the collections shall be removed no further rent of the buildings shall be paid, and any unexpended balance shall be used to pay for the removal. The collections still occupy the buildings, the expenses named in connection with their custody and safe-keeping are incurred. The other duties specified in the memoranda, as well as additional ones, especially in the requirement to make an annual report on the condition of the work, are being performed as may be shown in part by the recent publication of a volume of the paleontology, and the performance of work pertaining to the other volumes can be shown if required.

In my contract with the trustees of the State museum under the laws of 1883 for the authorship of the paleontology, it is provided that my compensation shall be from this appropriation and is not to be paid from the appropriation for the publication of the paleontology. The same is true regarding the payment for the original drawings on the work.

It will not be practicable to fit up rooms in the State hall for the reception of these collections during the present year, and in the meantime these buildings which I provided must remain occupied as heretofore and the necessary expenses of their custody be incurred. In my first statement of the costs and expenses pertaining to the care and custody of these collections, and the preparation of the work upon the paleontology, the estimates were all upon the most economical scale, and I am quite sure that the collections can never be so well and so economically cared for in any public building as they have been while in my custody.

In this arrangement with the State I have endeavored to perform my part of the contract faithfully and conscientiously, and while the same conditions and requirements continue I can see no reason why the State should annul the existing arrangement.

I have here endeavored to state, as concisely as possible, the principal facts in this case. I shall be ready to give any further information which may be required and I would feel very thankful if your excellency will make a thorough inquiry into all the facts connected with this matter, and the conditions past and present under which these collections have been accumulated and the work carried on to its present state.

I am, very respectfully, your obedient servant.

(Signed) JAMES HALL.

In 1889 the State museum was made an integral part of the University of the State of New York, and the section of the law which specially relates to the affairs of the museum says:

> All scientific specimens and collections, works of art, objects of historic interest and similar property appropriate to a general museum if owned by the State and not placed in other custody by specific law shall constitute the State museum, and one of its officers shall annually inspect all such property not kept in the State museum rooms and the annual report of the museum to the legislature shall include summaries of such property with its location and any needed recommendation as to its safety or usefulness.

Together with the other departments of the university, the museum became a constitutional body in 1895, and in the revised university law of 1896 the functions of the organization are defined as already given.

In 1885 Dr. John C. Smock was appointed assistant in charge of the State museum under the directorship of Prof. James Hall. Professor Hall resigned his position as director of the State museum in 1894 and was succeeded by Dr. F. J. H. Merrill, who had previously held the position of assistant director from 1890. Upon the death of Professor Hall in 1898 Doctor Merrill was also appointed State geologist.[1]

Expenses.—The following statement includes the annual and total expenses of the museum and survey from the beginning in 1836 to 1887:

Paid up to January, 1850	$425,375.76
Paid up to January, 1850, for printing annual reports	19,530.30
Appropriated July 15, 1853, for arrearages, publication	20,000.00
Appropriated July 15, 1853, for printing	10,000.00
Appropriated Apr. 14, 1855, expenses	5,000.00
Appropriated Apr. 15, 1857, James Hall, salary	2,000.00
Appropriated Apr. 15, 1857, for collecting	1,000.00
Appropriated Apr. 19, 1859, J. Hall, salary	2,000.00
Appropriated Apr. 19, 1859, expenses	9,642.75
Appropriated Apr. 16, 1860, J. Hall, salary	2,000.00
Appropriated Apr. 16, 1860, collecting	1,000.00
Appropriated Apr. 13, 1861, collecting	1,000.00
Appropriated Apr. 13, 1861, salary, J. Hall	2,000.00
Appropriated Apr. 16, 1861, drawings	1,000.00
Appropriated Apr. 23, 1862, salary, J. Hall	2,000.00
Appropriated Apr. 23, 1862, collecting	1,000.00
Appropriated Apr. 23, 1862, drawings	1,000.00
Appropriated Apr. 15, 1863, three items as above	4,000.00
Appropriated Apr. 22, 1864, three items as above	4,000.00
Appropriated Apr. 28, 1865, J. Hall, rent of room, fuel, etc., for seven years	3,500.00
Appropriated Apr. 28, 1865, J. Hall, for collecting	1,000.00
Appropriated Apr. 21, 1866, J. Hall, for services	3,000.00
Appropriated Apr. 10, 1866, drawings	2,000.00
Appropriated Apr. 22, 1867, Hall, services	2,000.00
Appropriated Apr. 22, 1867, drawings	1,500.00
Appropriated May 8, 1868, deficiencies	5,000.00
Appropriated May 10, 1869, J. Hall	3,000.00
Appropriated May 6, 1869, drawings	2,500.00
Appropriated May 10, 1869, Hall, compensation as curator, etc	10,000.00
Appropriated Apr. 19, 1870, Hall, compensation as curator	3,500.00
Appropriated Apr. 19, 1870, Hall, assistants	2,500.00
Appropriated Apr. 19, 1870, drawings	2,500.00
Appropriated Apr. 19, 1870, collections	1,500.00
Appropriated Apr. 26, 1871, Hall, for rooms, fuel, etc	1,000.00
Appropriated Apr. 26, 1871, Hall, for distributing duplicates	2,500.00
Appropriated Apr. 26, 1871, Hall, for drawings	2,500.00

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[1] Twenty-fourth Rep. State Geol. of N. Y., 1904.

Appropriated Apr. 26, 1871, Hall, for salary of director, three assistants, increase of collections	$10,000.00
Appropriated Apr. 14, 1877, Hall, as in 1872–1875	2,500.00
Appropriated May 29, 1873, Hall, for authorship and superintendence	2,500.00
Appropriated May 9, 1874, Hall, for authorship and superintendence	2,500.00
Appropriated May 17, 1875, Hall, for authorship and superintendence	2,500.00
Appropriated Apr. 29, 1876, for drawings	2,500.00
Appropriated Apr. 14, 1877, Hall, as in 1872–1875	2,500.00
Appropriated Feb. 25, 1878, Hall, as in 1872–1875	2,500.00
Appropriated Feb. 25, 1878, drawings	1,800.00
Appropriated Apr. 5, 1879, same as in 1878	4,300.00
Appropriated Apr. 22, 1880, same as in 1878	4,300.00
Appropriated Apr. 21, 1881, same as in 1878	4,300.00
Appropriated June 3, 1882, same as in 1878	4,300.00
Appropriated June 16, 1883, same as in 1878	4,300.00
Appropriated June 14, 1884, same as in 1878	4,300.00
Appropriated June 14, 1884, for publication and reports	15,000.00
Appropriated May 8, 1885, for J. Hall	2,500.00
Appropriated May 8, 1885, for drawings	1,408.00
Appropriated May 8, 1885, for publication	15,000.00
Appropriated May 18, 1886, Hall	1,200.00
Appropriated May 18, 1886, Hall, for rent of room	1,300.00
Appropriated May 18, 1886, Hall, drawings	1,408.00
Appropriated Apr. 23, 1887, for printing	15,000.00
Total	$670,964.81

The personnel and salaries for 1888 were as follows:

Museum staff.

James Hall, director	[1] $3,500
Joseph A. Lintner, entomologist	[1] 2,000
Charles H. Peck, botanist	[1] 1,500
John C. Smock, assistant in charge[2]	2,000
William B. Marshall, assistant in zoology	1,000
Charles E. Beecher, consulting paleontologist[3]	600
Jacob Van Deloo, clerk and messenger	480
Martin Sheehy, rock cutting and general help	780

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[1] These salaries were originally fixed by act of legislature.

[2] Mr. Smock was appointed assistant in charge by the following resolution of January 7, 1885:

Resolved, That in order to relieve Director Hall from the details of labor in connection with the State museum and enable him to devote his time to the preparation of the volumes of paleontology yet to be published, the position of assistant in charge be hereby instituted, and that the person appointed thereto be charged with the duty, under the control and supervision of the director, of managing the affairs of the museum and of preparing for and conducting the removal of the museum to the old State hall.

Resolved, That Prof. John C. Smock be appointed assistant in charge of the State museum at a salary of $2,000 per annum, to commence from the first day of April, 1885, and that he be requested to perform such portion of his duties in advance of that date as his present engagement will permit, at such compensation as the museum committee may fix.

[3] The duties of this office are not defined and results not recorded.

Denison Olmsted

GEOLOGIST OF NORTH CAROLINA, 1824-25.

NORTH CAROLINA.[1]

As early as 1819 a board of internal improvements was organized by an act of the general assembly for the purpose of taking charge of recently inaugurated public works, relating mainly to the improvement of internal navigation. During the period from 1821-1843 surveys were made of all rivers east of the Blue Ridge, and during that time and subsequently numerous surveys at public expense were made for railroads, turnpikes, and canals. The field notes, drawings, and plans of these surveys have not been preserved, and as they were necessarily crude they are referred to here as of only historical interest. Incidentally, however, the board was directed to make surveys of the numerous swamp areas of the eastern portion, owned by the State, for the purpose of determining their area, practicability, and cost of drainage, as well as their possible value for agricultural purposes. Some 800,000 acres are said[2] to have been surveyed, but the results have proved to be of slight practical value.

The first attempt at a survey coming properly within the scope of the present history was that inaugurated by Prof. Denison Olmsted in 1824, and continued by him and Prof. Elisha Mitchell until 1828. This was followed in 1852-1864 by a survey by Ebenezer Emmons, and this again by one by W. C. Kerr, the latter, however, being in fact a renewal of the Emmons survey after the death of Emmons and the close of the Civil War.

THE OLMSTED-MITCHELL GEOLOGICAL SURVEY, 1824-1828.

In a letter laid before the board of public improvements in North Carolina, August 1, 1821, Denison Olmsted, of Connecticut, at that time professor of chemistry, geology, and mineralogy in the University of North Carolina at Chapel Hill, proposed to devote his vacations to the making of a geological and mineralogical survey of the State, and asked for merely such an appropriation as might be necessary to defray the expenses of the undertaking, naming the sum of $100 a year as sufficient for the purpose. The following is the full text of his letter as given in the minutes of the Board of Internal Improvements of North Carolina, August 1, 1821:

To the Hon. Board of Internal Improvements:

Among the objects which solicit the attention of the board for developing and extending the internal resources of the State, I beg leave to present to their notice the advantages that would result from investigating its geology. By this, as connected with the subject of internal improvements, I mean such an investgation as would furnish to the board and the public an account of the various useful productions of the mineral kingdom, which either have been discovered already, or which may, from certain well-known indications, be reasonably expected to be found hereafter. Such are the following:

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[1] Compiled in part from manuscript by J. A. Holmes.

[2] Report on Swamp Lands of North Carolina, by W. C. Kerr.

1. Different kinds of stone made use of in buildings, as freestone, slate, limestone, and soapstone; marble, serpentine, etc.

2. Beds of gypsum, salt, coal, marl, potters clay, and other fossils used in agriculture or domestic economy.

3. Beds of ocher, bole, reddle, plumbago, and similar substances used in painting.

4. Metallic ores, as iron, lead, antimony, zinc, etc.

5. Mineral springs.

It is superfluous for me to say, that these substances are of great importance to the public both for domestic uses, and, under favorable circumstances, as articles of commerce.

That they are also very intimately connected with the improvement of internal navigation will be obvious, if we reflect, that, by a free navigation, their value as articles of exports is, like that of the productions of agriculture. greatly enhanced; that were we in possession of marbles equal to those of Greece and Italy, their commercial value would be lost by the difficulty of transportation; while with a free navigation, many things of which we are now in the actual possession, might be turned to much more profitable account. As, therefore, the treasures of the mineral kingdom (in which there is reason to think this State is as opulent as any in the Union) are exhibited to the view of the public, the necessity and advantages of internal navigation will be most strikingly manifest.

But all these things are so obvious that it is only necessary for me to show, that an actual examination of the country, conducted with the requisite knowledge of the geological principles, will have a tendency to multiply the discoveries, and extend the uses of these valuable substances.

1. Many valuable minerals now lie neglected, because their nature and uses are not generally known.

2. Geology furnishes rules for discovering useful minerals by certain known indications, derived from other minerals in the neighborhood, from the general structure of the country, and so on. It materially aids the progress of discovery by showing whether a given mineral, as gypsum, for instance, is to be looked for in a particular section of country, or not. It thus limits the field of examination and prevents fruitless researches.

3. So fully have the advantages resulting from such investigations been experienced in Great Britain that landed proprietors frequently cause them to be made on their own estates.

4. In the State of New York where public enterprise is directed to the objects as those which this honorable board have in view, the geological examination of the country, through which their operations are carried on, has been attended with highly important and beneficial results, as will be seen by reference to the late speeches of his excellency the governor of New York, to the legislature of that State.

Should the honorable board be of opinion that the objects specified in this communication are worthy of their attention and patronage, I hereby offer them my services during such seasons of leisure as can be spared from the exercise of my official duties at the university, and ask merely such an appropriation as shall defray the expenses of the undertaking.

These would be chiefly such as would accrue from the hire of a horse and servant and the charge of traveling, consequently they could not be great. I would beg leave respectfully to name $100, to be afterwards renewed or not at the pleasure of the board.

The time occupied in these researches, would generally coincide with the college vacations.

The acquisition of knowledge, by which I might be better able to fulfill the duties of my profession and the opportunity of furnishing a geological description of this hitherto undescribed country to the American Geological Society, of which I have the honor to be a member, would afford all the recompense I require; and the collection of specimens to illustrate my lectures, as well as an increased ability to impart information to my pupils respecting their native State, would be the means of securing some advantages to the university.

My objects, then, are twofold; so far as respects the board, they would be wholly practical; as it respects myself personally, the promotion of science, by which the natural history of the State may be better known and appreciated, both at home and abroad, is a great object though not at all at variance with the other.

In accordance with these views in reporting to the board the results of my labors I should expect to notice such topics as the following, together with such other topics as they should particularly prescribe:

Stones for building.—Example, freestone; qualities by which it may be known; what kinds are suitable for building; what kinds unsuitable; other uses to which the stone is or may be applied. Wherever the best mode of quarrying or working did not appear to be understood, that mode might be particularly described. A similar plan might be pursued with respect to ornamental stones, as marbles, jasper, porphyry, or as to metallic ores. Other things of practical importance that had fallen under observation might be particularly specified; the limit of rock formations pointed out; the places designated which lie in the range of known quarries, where it is probable they may be found to appear again.

The relative value of such substances as might become articles of commerce might be ascertained; the nature of mineral springs already celebrated might be investigated and others which appear to be valuable made known, and all similar information might be communicated which could be collected on such excursions.

The board did not consider itself authorized to make the contract with Mr. Olmsted, but referred the matter to the general assembly, recommending that his proposition be accepted.

The legislature took no action in the matter at that time. The proposition was, however, renewed by Professor Olmsted in 1823, the result of which was the passage of an act authorizing the board of agriculture to have such a survey made, and appropriating for the purpose the sum of $250 a year for four successive years. At the end of that time (session of 1827–28) the legislature passed an act continuing the appropriation for another year.

The following is a transcript of this act:

An act directing a geological and mineralogical survey to be made of the State of North Carolina.

I. *Be it enacted by the General Assembly of the State of North Carolina, and it is hereby enacted by the authority of the same,* That it is hereby made the duty of the board of agriculture of North Carolina to employ some person of competent skill and science, to commence and carry on a geological and mineralogical survey of the various regions of this State; and that the person or persons so employed shall, at stated periods, furnish to the board true and correct accounts of the results of said surveys and investigations, which shall annually be published by the board aforesaid, for the benefit of the public, as provided by the sixth section of the act of the last general assembly, entitled "An act to promote agriculture and family domestic manufactures within this State."

II. *And be it further enacted,* That for the purpose of carrying the intention of the foregoing section into effect, a sum not exceeding $250 be, and the same is hereby, annually appropriated for four successive years, out of the unexpended balance of the agricultural fund, as created and set apart by the above recited act; and that the treasurer of the State is hereby directed to pay the same to the order of the board of agriculture of Norh Carolina.

The above law stood without change throughout the whole period of the existence of the survey.

Connection with other institutions.—The survey, if such it can be called, had no immediate connection with any other institution than the board of agriculture, though both Olmsted and Mitchell held professorships in the State university, and the collections made became the property of the university.

Administration.—Professor Olmsted was appointed by the board to conduct the survey and prosecuted the work during portions of the years 1824 and 1825. At the end of that time he resigned, both his position on the survey and his professorship in the university, and Prof. Elisha Mitchell, then professor of mathematics in the university, was appointed to fill the positions thus left vacant. Professor Mitchell appears to have continued the work during his college vacations of the years 1826, 1827, and 1828, at the end of which time the work was permanently discontinued.

The personnel of the survey was as follows: 1824 and 1825, Denison Olmsted, geologist; Charles E. Rothe, assistant geologist; 1825–1828, Elisha Mitchell,[1] geologist.

During a part of the year 1825 Professor Olmsted employed, with the approbation of the president of the board of agriculture, Charles E. Rothe (a miner and mineralogist recently from Saxony) to visit the counties of Person, Mecklenburg, and Anson in this State and examine the slate formations on the lines of Virginia and South Carolina.[2]

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[1] In a communication published in the American Journal of Science (vol. 16, No. 1, 1829) Professor Mitchell writes that for three years, beginning with the latter part of 1825, Prof. E. A. Andrews (at that time professor of languages in the University of North Carolina, and afterwards well known as a grammarian and lexicographer) was associated along with himself in an examination into the geology of the State; but no mention has been found of Professor Andrews having been directly connected with the work of the survey. He may, however, have assisted Professor Mitchell in that work.

[2] Olmsted, Report on the Geology of North Carolina, part 2, 1825, pp. 105 and 106.

As to the methods adopted in the prosecution of the survey little information has been left on record. They were unquestionably of the simplest character. Olmsted, during 1824, seems to have devoted himself mainly to the middle section of the State, searching particularly for minerals of economic value, but with little regard for the geological structure as a whole. The same may be said of Mitchell. Though working for a longer period, he succeeded in gathering up a larger and more systematic series of data, from which he was later enabled to compile a geological map of the State.

Museum or cabinet.—There was nothing in connection with the survey which could be called a museum. Professor Mitchell mentions in his report[1] "the cabinet" of the university, where a rather complete series of specimens illustrative of the geology of the counties visited had been assembled. At the present day, however, no remnant of this collection is to be found.

There was no library belonging to the survey and no "exchanges" to be disposed of.

Salaries and expenses.—Obviously, neither Olmsted nor Mitchell could have received any salary for their work, the amount appropriated being only for expenses, nor has there been found any record of any payment to Mr. Rothe. No record of the detailed expenditures of the survey has been found. The report of the State auditor and treasurer (1824–1828) reads as follows: "Paid D. Olmsted by State treasurer for geological survey * * * , etc."; and in case of Professor Mitchell, "To Professor Mitchell for his services and expenses in making a geological survey of the State, agreeable to the direction of the general assembly, on warrant from the president of the board of agriculture, * * * $250."

The total expenditures for the five years (excluding cost of publications) amounted to $1,250. The expenditures for printing were paid out of the general fund of the State treasury.

Publications.—The publications of the survey consisted of small annual reports; these, four in number, were each printed as a part of a volume of reports and essays published annually under the direction of the board of agriculture. They are as follows:

Report on the Geology of North Carolina, part 1. By Denison Olmsted. (Raleigh) 1824. 12mo. 44 pp.

Report on the Geology of North Carolina, part 2. By Denison Olmsted. (Raleigh) 1825. 12mo. 60 pp.

Report on the Geology of North Carolina, part 3. By Elisha Mitchell. (To which is added a paper on the Gold Mines of North Carolina, by C. E. Rothe, reprinted from Silliman's *Journal* of 1828.) (Raleigh) 1827. 12mo. 42 pp.

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[1] Geology of North Carolina, part 3, pp. 5–17.

Geological Report of Professor Mitchell. (Raleigh) 1829. 12mo. 8 pp.

Of the reports for 1824, 1825, and 1827, 1,500 copies each were printed. As to the report for 1829, the record fails to indicate the number of copies. The reports were distributed free, "by means of agricultural societies, to the people of the State," and there is no record of any publications having been sold.

Benefits.—As to the material benefits resulting to the people of the State, it is probable that mining enterprises and investments were in a small measure stimulated and directed, and an interest in better methods of agriculture awakened and strengthened.

The attention of the people of the eastern section of the State was called to the occurrence and use of marls in their section, but there is no available evidence of any benefits resulting therefrom. From an educational standpoint the survey was a benefit, in that the people were informed through the reports of the survey as to the general geology and mineral resources of the State.

After the discontinuance of the survey (1828), Professor Mitchell for several years made geological explorations to different portions of the State at his own expense. The general results of these he published in a small textbook, Elements of Geology, with an outline of the geology of North Carolina, 1842 (12mo. 141 pp.), with a geological map of the State. This was the first map of the State published, though the area was included in Maclure's maps of 1809 and 1817. It was probably an outgrowth of one begun by Professor Olmsted in 1824, which received corrections and additions by Professor Mitchell during the succeeding years to the time of its publication. No official geological map of the State was published from that date (1842) until the appearance of the one accompanying Kerr's Report in 1875 (Geology of North Carolina, vol. 1).

SECOND SURVEY UNDER EBENEZER EMMONS, 1852–1864.

No work in the direction of a scientific survey of the State was undertaken from the discontinuance of the Olmsted-Mitchell survey in 1828 until 1852, when the Emmons survey was begun. The need of a survey in connection with the mining and mineral interests of the middle and western section of the State, and the agriculture and geology of the entire area had, however, been felt for many years prior to this date, and its institution advocated by leading public men. The advantages of the work had been pointed out in the executive messages of Governor Dudley in 1838, Governor Morehead in 1844, Governor Graham in 1846 and 1848, and Governor Manly in 1850–51.

At its session of 1848–49 the general assembly had authorized a corporation under the name of the "Cape Fear & Deep River Navigation Co." to make said river navigable above Fayetteville, to and above the coal fields in Chatham County, it being believed at that time that there were extensive deposits of coal and iron in that region, and there was naturally a strong desire on the part of the corporation and the people owning lands in the region for a systematic survey of the area. For several years, too, considerable excitement had prevailed in the western section of the State in connection with mining interests, especially those relating to copper.

At its session of 1850–51 the general assembly of the State, acting presumably under the recommendation of Governor Manly, passed an act authorizing a geological, mineralogical, botanical, and agricultural survey to be made. The following is a transcript of this act:

An act to provide for a geological and agricultural survey of the State.

SECTION 1. *Be it enacted by the General Assembly of the State of North Carolina, and it is hereby enacted by the authority of the same,* That the governor shall, as soon as practical, select and appoint some suitable person to conduct, under the general supervision of himself and the literary board, a geological, mineralogical, botanical, and agricultural survey of the State.

SEC. 2. *Be it further enacted,* That it shall be the duty of the person so selected and appointed to examine and survey each and every county of the State; to ascertain the different geological formations of each county and section of the State; the nature, character, and value of its minerals; the nature and character of its soils and the best method of improving the same; the nature and kind of its productions and their position and relative value; its facilities for manufactories; the extent and value of its water power; the character and value of its botanical productions; the character and value of its timber; and all other facts connected with the subjects of geology, mineralogy, botany, and agriculture which may tend to a full development of the resources of our State; and that the said person so selected and appointed to conduct said survey shall be authorized to employ such agents and assistants, to be approved of by the governor, as may be necessary to enable him speedily and successfuly to accomplish the objects committed to his charge; and he shall, from time to time, communicate to the governor, to be by him communicated to the legislature, a report or reports, in writing, setting forth fully the results of his survey, which reports shall be published under the supervision of the governor and literary board.

SEC. 3. Be it further enacted, That the expenditures incurred by said survey shall not exceed $5,000 per annum, to be paid by the public treasurer upon the warrant of the governor, out of any moneys in the treasury not otherwise appropriated.

SEC. 4. *Be it further enacted,* That it shall be the duty of the person making such survey to deliver lectures upon the subjects committed to his charge in the villages through which he shall pass: *Provided,* That he shall not thereby delay his other duties.

Ratified January 24, 1851.

No modifications of this law or other legal measures affecting the survey are found on record between 1851 and its discontinuance in 1864.

Connection with other institutions.—The Emmons survey was not officially nor directly connected with any other institution from the time of its organization in 1852 to its suspension (1864).

Personnel.—Ebenezer Emmons was State geologist from 1852–1863, with the following assistants: E. Emmons, jr., assistant geologist, 1852–1864; Spence McClenahan, assistant geologist, 1852–1854; J. F. Tompkins,[1] assistant geologist, 1853–1854; M. B. Conklin, assistant geologist, 1857–1860; C. D. Smith, assistant geologist, 1858–1860; M. A. Curtis, naturalist, 1859–1863; and R. H. Northrup, assistant geologist, 1863–1864.

Manner of appointment.—In accordance with section 1 of the act of 1851 authorizing the survey, the chief geologist was appointed by the governor of the State. In accordance with section 2 of the same act the assistants were appointed by the geologist, subject to the approval of the governor. So far as the record shows no system of promotion was adopted in connection with the appointment of assistants to positions on the survey.

Salaries.—The salary of the geologist, as fixed by agreement between himself and the governor, was $2,500 a year. The salaries of the assistants were as follows: E. Emmons, jr. (1852–1864), $1.500 a year; Spence McClenahan (1852–1854), $1,200 a year; J. F. Tompkins (1853 or 1854), $100 a month; M. B. Conklin (1857–1860), $600 a year; C. D. Smith (1858–60), $50 a month; M. A. Curtis (1859–1863), $500 a year.

Administration.—Under the law of 1851 Prof. Ebenezer Emmons, professor of geology in Williams College, Massachusetts, was appointed State geologist. He entered upon his duties in January, 1852, and gave the work his chief attention, though nominally retaining his position at Williams College, and for several years delivering a course of lectures at that institution.

As to the methods of operation adopted by the survey under Emmons, the available information is not sufficient to warrant the attempt at writing even a brief sketch. Under the circumstances only a few general statements can be made. The greater part of the work of the survey in the field, office, and laboratory was done by Professor Emmons and his son, E. Emmons, jr., who was the only permanent assistant, other assistants having been usually employed to do field work in regions of the State with which they were familiar or for some specific work. The general plan of operations was an outgrowth of this fact, together with the nature of the work to be done. Doctor Emmons was a man of wide training, and brought all his varied knowledge into use. He was geologist, mineralogist, chemist, agriculturist, and, to a certain extent, paleontologist. His assistants, with the exception of the botanist, were not specialists along any lines, but simply worked under his immediate direction. Naturally, with such varied duties, the general work of the survey suffered.

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[1] Exact date of his connection with the survey uncertain.

No topographical work was attempted except that in making one or more geological sections of proportional heights, a series of barometric observations were made along the line of the proposed sections, as was done along a line across the mountain region of the State, from the valley of the Yadkin to the Tennessee line on the route of the French Broad River. No work in botany or zoology was carried on by the survey except that done by Doctor Curtis. This consisted mainly in writing up the results of observations previously made. The work done by the survey in both the field and office was chiefly in connection with the general geology, and the mining and agricultural interests of the State. In the field work each of these three departments was kept in view according to its importance in the region visited. In the eastern region of the State, where there are no mines, the observations related mainly to the agriculture and paleontology; in the middle region, to the agriculture, mines, paleontology (of the coal fields) and general geology; and in the extreme western region, the same excepting the paleontology.

The work in agriculture included the making of observations as to the nature and fertility of the soil and the crops produced, collecting specimens of soils for analysis, etc. These specimens were sent to the laboratory of the survey at Raleigh. In some cases, in addition to the sample of soil, specimens of the plants growing thereon were collected and both subjected to chemical analyses.

The examination of fossils, identification of known species and description of new species was all done by Professor Emmons. Drawings of fossils, maps, and geological sections were made by E. Emmons, jr. The chemical work was done mainly by Professor Emmons in person, as already noted, in a private laboratory connected with his residence in Raleigh.

During the latter years of the survey (1861–1864) the attention of the geologist and his assistants was turned to the manufacture of munitions of war, especially fulminate of mercury, for the use of the State military forces. This fact and the ill health of Doctor Emmons caused the proper work of the survey to be practically given up during this time.

Museum or cabinet.—The collections made during the prosecution of the field work of the survey were carried to Raleigh, the headquarters of the survey, and deposited in a room set apart for that purpose in the capitol building. In addition to these, many other specimens were sent by persons living in different parts of the State, so that toward the close of the survey a large amount of material had been collected. The cabinet thus formed was considered at the time (1858–1860) one of considerable value. It remained in the capitol building until the close of the Civil War, when the remnant was by act of the general assembly transferred to the State university at Chapel Hill. During his connection with the survey Doctor Emmons also made a large private collection of minerals and fossils, which was sold to Williams College, Massachusetts.

There was no library belonging to the survey.

Expenses.—The funds at the disposal of the survey were expended mainly in the payment of the salaries of the geologist and his assistants and the publication of reports. It included also the preparation and repairs of the room to contain the cabinet of minerals, and a few other items of less importance.

The salaries of the geologist and his assistants were fixed by agreement between the governor and Professor Emmons. (See p. 370.) Out of these they were required to bear the expenses of the field work, the analyses of soils, and the outlay for chemicals.[1]

The expenditures during the existence of the survey were as follows: For fiscal years ending October 31, from 1852 to 1856, and September 30, 1857 to 1864, inclusive: 1852, $2,875; 1852–53, $5,125; 1853–54, $4,763.57; 1854–55, $4,203.27; 1855–56, $5,749.42; 1856–57, $4,000; 1857–58, $6,361.40; 1858–59, $5,458.30; 1859–60, $5,838.59; 1860–61, $4,546.67; 1861–62, $4,500; 1862–63, $4,138.88; 1863–64, $1,051.50.

The total expenditures of the survey during its existence (1852–1864) amounted to $58,611.60. This includes the cost of engraving and printing.

As noted, the survey was sustained by an annual appropriation of $5,000 from the general treasury of the State, which was continued until otherwise ordered.

Publications.—The following list shows the size of the editions and cost of publication of the various reports, so far as obtainable. As has been frequently found to be the case, the cost is charged up with the State printing fund and no separate account rendered:

1852. Report of the Survey; 181 pp.; edition, 5,000 copies; cost, $990.

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[1] Report of Geological Survey of North Carolina, Leg. Doc., Sess. 1854–55, p. 3.

1856. Report on Geology of Midland Counties; edition of 1,000 copies; cost, $1,801.82.

1858. Report on Geology of Eastern Counties; 314 pp.; edition of 2,000 copies; cost, $1,322.12.

1867. Report of Geological and Natural History Survey; part 3: 158 pp.; edition of 1,000 copies; cost, $402.90.

At the beginning of the Civil War and during several years previous to that date (1861) Professor Emmons and his assistants appear to have been engaged mainly in the prosecution of the chemical and other office work and preparation for publication of a series of final reports, with accompanying maps, embodying the results of the survey. Doctor Curtis, the assistant in natural history, had in preparation from 1860 to 1863 a series of reports on the botany and zoology of the State.

Of the reports in preparation, three were published in 1860. The publication of the others was interrupted by the excitement attending the breaking out of war.

As to the nature and extent of these unpublished reports prepared by himself, Doctor Emmons says:[1]

> It was estimated that sufficient matter had accumulated to make about 1,200 or 1,300 octavo pages, embracing subjects relating to the agriculture of the midland, western, and mountain counties; the mining resources of the mountain counties and additional facts relative to the mineral resources of Deep River and the midland counties, together with a report on the grape, which is peculiar to a section which we may properly call the wine district of North Carolina.

The manuscript for the reports mentioned in the above extract appears to have been lost or destroyed at about the beginning of or during the war. It is stated that Professor Emmons presented a manuscript report for publication to Governor Ellis in 1861, and that soon after the report had been deposited in the executive office for publication it was in some unexplained way lost or destroyed.

To accompany the above-mentioned reports of Professor Emmons, there was in preparation by Mr. E. Emmons, jr., a geological map of the State, and also one of the coal fields. The latter was colored, and ready for publication in 1861, but the geological portion was in preparation but far from complete. The map used as a base for the geological map was one by W. D. Cooke, published in 1857 (by Colton & Co.); scale, 8 miles to the inch. These maps were all left in Raleigh and are supposed to have been lost or destroyed during the Civil War.

In addition to the above, the following unpublished reports were prepared under the auspices of the survey:

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[1] Report to Governor Ellis, Leg. Doc. 1860–61, p. 5.

Report of a geological reconnoissance of that portion of North Carolina west of the Blue Ridge, south of and including Buncombe County. By C. D. Smith. 1860.

Reports of Dr. M. A. Curtis, including a Catalogue of Plants of North Carolina;[1] a Description of the Quadrupeds; a Description of the Reptiles; and (in preparation) a Description of the Birds of North Carolina.

Mr. Smith's report was made and presented to Professor Emmons in 1860 and incorporated with the report of the latter presented to Governor Ellis in 1861, and was lost or destroyed along with that report.

Benefits.—It is impossible to estimate the material benefits that have resulted to the people of the State from the prosecution of this survey. At the time the results should have fairly begun to be realized the war came on, and public enterprises looking to the development of the natural resources of the State were stopped, the influx of people or capital for several years thereafter was out of the question, and the geological survey as such was suspended.

Professor Emmons himself claimed [2] that the beneficial results were considerable in that (1) it "discouraged undertakings which would have resulted in failure," and thus saved large sums of money which would have been lost, and it stopped those works where money was being wasted upon hopeless prospects; and (2) by making careful examinations of mineral properties as to the value of which there were favorable indications, and publishing the results of such examinations, enterprises likely to prove successful were encouraged. Proper direction was given to the investment of capital at home, and capital from abroad was brought into the State.

Concerning the additions to science made by this survey, it may be said that the character and the outlines of the geological formations of the State were described more fully than had been done before. The investigations of the fossil flora of the Mesozoic coal deposits resulted in the discovery, according to recent determination, of 39 species, nine of which appear to be peculiar to North Carolina.[3] The investigations in connection with the animal remains of the Tertiary and Mesozoic deposits resulted in adding to science, directly or indirectly, according to the list given by Cope,[4] four species of fossil fish, one batrachian, eight reptiles, and four mammals.

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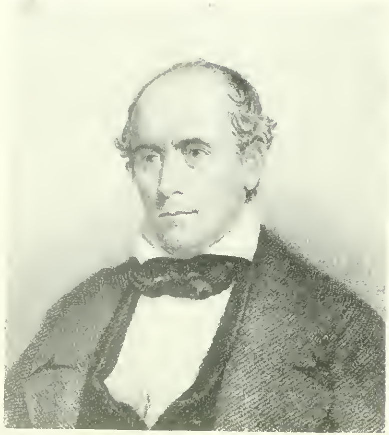
[1] Published in 1867.

[2] Report of Progress, 1855, pp. 7–13. Geology of Midland Counties of North Carolina, 1856, p. xix, and Report of Progress, 1860, p. 2.

[3] Fontaine, Older Mesozoic of Virginia, pp. 122 and 123. See also Emmons's Geology of Midland Counties of North Carolina, 1826; and American Geology, pt. 4.

[4] Kerr's Geology of North Carolina, 1875. Appendix B.



ELISHA MITCHELL, 1827-28

WASHINGTON CARUTHERS KERR, 1866-82

JOSEPH AUSTIN HOLMES

STATE GEOLOGISTS OF NORTH CAROLINA.

Among the discoveries in paleontology the most interesting was the insectivorous mammal, *Dromatherium sylvestre*,[1] found in the Triassic (older Mesozoic) coal measures of Chatham County.

THIRD SURVEY UNDER W. C. KERR, 1864–1882.

The survey under W. C. Kerr was in reality a continuation of that begun under Emmons in 1852. Doctor Emmons died in October, 1863. The assistant geologist, E. Emmons, jr., resigned April 1, 1864, at which date the appropriations for the expenses of the survey were discontinued.

Organization.—Kerr was appointed State geologist in 1864 (exact date not known), but no appropriation was made for the expenses and no geological work was undertaken. His time was fully occupied in advising and directing in connection with the manufacture of salt, saltpeter, copperas, sulphur, sulphuric acid, medicinal extracts from plants, and various other substances needed for purposes of home consumption or for purposes of war. After the close of the war (April, 1865) even this nominal connection appears to have been given up, and the survey discontinued for a year.

On April 1, 1866, Kerr was reappointed State geologist by Governor Worth, and the survey was reorganized under the same law as formerly. From this date the work continued without any serious interruption until August, 1882, when Kerr resigned the directorship to accept a position as geologist on the United States Geological Survey. From the latter date to September, 1883, the active work of the survey was suspended, though Mr. William B. Phillips acted as State geologist in the performance of office duties. In September, 1883, Kerr, owing to ill health, resigned his connection with the national survey, and from this date to the time of his death in August, 1885, he held a semiofficial position under the direction of the board of agriculture of North Carolina, and devoted such time as his declining health would permit to collecting the materials for the completion of his final report (vol. 2, Geology of North Carolina). From the date of Kerr's death until 1891 the geological survey had not even a nominal existence.[2]

Organized under the same law, the Kerr survey had in view the same general functions and purposes as that of Emmons, which had preceded it, namely, investigations into the general geology and natural history and the natural resources of the State.

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[1] See American Geology, pt. 6, p. 93.

[2] The law permitting the appointment of a geologist and the prosecution of geological work under the direction of and at the expense of the board of agriculture was not abolished until 1887, but nothing was undertaken by the board except in connection with the preparation of the geological report (vol. 2).

It was the first endeavor of Professor Kerr to determine what of the objects of the survey had been most fully accomplished during the administration of Doctor Emmons. It was found that his unpublished notes had been lost or destroyed, and hence that it would be necessary to reexamine in large part the field covered by him, as well as to survey the large western area, thus far almost unexplored. However, before the work in connection with the general geology could be completed, or indeed prosecuted to any great advantage, a topographic map was necessary. Concerning the middle and eastern divisions of the State it was found that data for this could be collected from previous geographical surveys of one kind or another, but in the western division much original topographical work would have to be done.

In the department of paleontology much more work remained to be done. Concerning this, in his report of progress for 1866, page 20, Kerr says:

> Neither the Tertiary fossils of the eastern counties nor the Mesozoic of the Deep River and Dan River coal beds, nor yet the supposed Azoic (so-called Taconic) organisms of the middle section have been fully and satisfactorily studied and illustrated.

It was a part of the plan of organization to form a museum of specimens illustrative of the fossils, rocks, minerals and mining products, soils and marls, animals, and plants of the State; also, in connection with the agriculture, to make additional analyses of soils and marls and undertake any other investigation which the interest of the people might demand in this direction.

It was also a part of the plan to organize meteorological stations in many counties for the purpose of determining as far as possible the general climatology of the State, and to investigate the water power and manufacturing advantages.

No modifications of the law of 1851 were enacted from the date of its passage in 1851 to the year 1877. There was, however, an act passed by the general assembly of 1871–72, ratified February 12, 1872, which in slight measure affected the duties of the State geologist as follows:

> An act to prevent fraud in the sale of commercial manures.
>
> SEC. 4. That any person or persons instituting suit against any such manufacturer for such damages may on the payment of $15 to the State geologist cause a full and accurate analysis to be made by him, a certificate of which shall be presumptive evidence of the chemical elements and ingredients contained in the sample of fertilizer so analyzed and of the package or parcel from which the sample was taken.

The above was amended by an act of the general assembly of 1873–74, ratified January 29, 1874, as follows:[1]

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[1] Laws of North Carolina, 1873–74, ch. lxlx, sec. 6, p. 96.

SEC. 6. That the State geologist, at the request of any person who shall pay him the sum of $15, shall sample any lot of fertilizer held or offered for sale in this State, and analyze or cause the same to be analyzed; and if he shall find therein evidence of a failure to comply with the provisions of this act he shall cause the same to be published in some agricultural or other public papers in the cities of Raleigh and Baltimore.

In the year 1877 an act was passed by the general assembly whereby the geological survey was made a cooperative department with the department of agriculture, organized at that time. So much of that act as relates to the geological survey is as follows:

An act to establish a department of agriculture, immigration, and statistics, and for the encouragement of sheep husbandry.

SEC. 13. The geological survey is hereby made and constituted a cooperative department with the department of agriculture, and the geological museum and the collections therein shall, at all times, be accessible to the said department. The geologist shall, as far as practicable, prepare illustrations of the agricultural industries, products, and resources of the State and arrange and care for such collections as the said department may make for this purpose. He shall also prepare abstracts of the survey from time to time as may be required for the use of the department in their handbook, and circulars for publication, in illustrations of the advantages of this State and in promotion of the general purposes of immigration.

In return for such service the State geologist may have all his samples of marls, soils, minerals, and other products analyzed by the chemist at the laboratory of the experiment station, free of charge.

SEC. 14. It is hereby made the duty of the State geologist, upon the recommendation of the board of trustees of the university to devote two months in each year at the seat of the university in the performance of such duties in instruction as the faculty may direct, and while employed in this capacity he shall constitute a member of the faculty.

At this time an act was passed by the general assembly repealing section 1 of the act of 1851 for the appointment of the geologist, and section 3 providing for the expenditures of and authorizing the reorganization of the survey. This act was ratified February 20. 1879, went into effect immediately and continued in force until 1887. Professor Kerr was reappointed State geologist under the new law, and was continued in office until his resignation in 1882.

In 1883 all then existing laws relating to the survey were codified. The following is a copy of the same taken from volume 2 of the code:

Law governing the operation of the survey, 1883–1887.

SEC. 2198. The geological survey is hereby made and constituted a cooperative department with the department of agriculture, and the geological museum and the collections therein shall at all times be accessible to the said department. The geologist shall, as far as practicable, prepare illustrations of the agricultural industries, products, and resources of the State, and arrange and care for such collections as the said department may make for this purpose.

He shall also prepare abstracts of the survey from time to time as may be required for the use of the department in their handbook, and circulars for publication in illustration of the advantages of this State, and in promotion of the general purposes of immigration. In return for such service the State geologist may have all his marls, soils, minerals, and other products analyzed by the chemist at the laboratory of the departemnt station, free of charge, and the board of agriculture is hereby authorized to pay the necessary expenses of the geological museum; and they may authorize and supervise the publication by the public printer of the second volume of the geology of North Carolina, as soon as ready, and may furnish the necessary maps and other engravings for its proper illustration; and in like manner they may authorize the printing by the public printer, in pamphlet form, for free distribution, such parts of volumes 1 and 2 as they may deem advisable; and they may furnish copies of volume 2 to State, college, and other public libraries, to geologists and other scientific men, and to every newspaper in the State; and shall furnish the secretary of the state a copy for each county, to be forwarded with other public documents to the clerk of the superior court and to other persons at the cost of paper and printing. The State geologist, at the request of the trustees of the university, shall, whenever the board of agriculture shall deem it not interfering with the regular duties of his office, deliver at the university a course of free lectures on the geology and mineralogy of this State.

Sec. 2209. The governor shall appoint, by and with the consent of the senate, a suitable person to conduct, under the supervision of the department of agriculture, immigration, and statistics, a geological, mineralogical, botanical, and agricultural survey of the State; such officer shall hold office for two years: *Provided*, That the person so appointed shall be liable to removal at any time by the governor, by and with the consent of the board of agriculture, immigration, and statistics.

Sec. 2210. The compensation of the person so appointed shall be fixed by the said department of agriculture, immigration, and statistics, but shall never exceed a greater rate than $2,000 per annum.

Sec. 2211. The expenditures incurred in making said surveys and reports shall be defrayed from the funds provided for the support and maintenance of the said department of agriculture, immigration, and statistics: *Provided*, That the sum hereby authorized to be used, including the salary or compensation of the person appointed to make said surveys, shall not exceed the sum of $5,000 per annum.

Sec. 2212. The person appointed shall examine and survey each and every county of the State and ascertain the different geological formations of each county and section of the State; the nature, character, and value of its minerals; the nature and character of its soils, and the best mode of improving the same; the nature and kind of its productions, and their position and relative value; its facilities for manufactories; the extent and value of its water power; the character and value of its botanical productions; the character and value of its timber; and all other facts connected with the subjects of geology, mineralogy, botany, and agriculture which may tend to a full development of the resources of the State; and such person is authorized to employ as many proper agents and assistants, to be approved by the governor, as may be necessary to enable him speedily and successfully to accomplish the objects committed to his charge; and he shall, from time to time, communicate to the governor, to be by him communicated to the general assembly, a report, in writing, setting forth fully the results of his survey; which reports shall be published under the supervision of the governor and board of education.

> SEC. 2213. The person making such survey shall deliver lectures upon the subjects committed to his charge in the villages through which he shall pass: *Provided*, That he shall not thereby delay his other duties.

The act of the General Assembly of North Carolina abolishing the survey in 1887 is as follows:

> SEC. 10. That so much of sections 2198, 2209, 2210, 2211, 2212, and 2213 pertaining to the State geologist as requires the department of agriculture to fix the compensation, regulate the expenditures, or pay out of their funds the salary and expenses of the State geologist shall be. and the same is hereby, repealed.

From its reorganization under Kerr in 1866 to the year 1877 the survey was in no sense connected with other institutions, and the State geologist held no other official or professional position. At the latter date a department of agriculture was established, the geological survey made a cooperative department thereof, and the State geologist was made a member of, and an officer under the board of agriculture. And by section 14 of the same act it was made the duty of the State geologist, upon the recommendation of the board of trustees, to devote two months of each year to giving instructions to classes at the State university, and while employed in this capacity he was considered a member of the faculty of the university.

The above-mentioned act of 1877 continued in force for two years. In 1879 it was so amended that the State geologist was no longer a member of the board of agriculture, and though he was still required under certain conditions to deliver a course of lectures at the State university, he was not at such times to be considered a member of the faculty. By that act, however, the geological survey was continued a cooperative department of the department of agriculture.

The survey was sustained by an annual appropriation. From the time of organization (1866) to 1877 this appropriation was paid out of the general funds of the treasury as authorized by act of the general assembly of 1850-51. From 1877 to 1887 the funds for the expenses of the survey were appropriated out of money raised for the support of the department of agriculture by special tax on the manufacture and sale of commercial fertilizers within the State.

Administration.—Upon the reorganization of the survey in 1866 so great was the variety of the work to be undertaken that, with a small appropriation at its disposal, it was necessary that the geologist should undertake in person investigations of a widely different character. This was especially notable in connection with the topographical work. There was no accurate geographical nor topographical map of the State, as already noted, upon which to lay down the geological data.

The appropriation for the maintenance of the survey was too small to admit of a separate survey being made. During almost the entire period of the existence of the survey, Professor Kerr, in making his excursions over the State, was, therefore, obliged to combine topographical and geological work, and this greatly retarded the geological work.

Again, the correspondence of the survey made a continuous demand upon the time of the geologist—a demand of more importance than can be realized by those unfamiliar with the facts in the case. This correspondence was undertaken by the geologist in person and often retarded in no small degree the progress of his work in other directions.

During the years 1873, 1876, and 1881, a considerable portion of the work of the survey was given to the making of collective exhibits, illustrative of the State's resources, at the Vienna, Centennial, and Atlanta expositions, respectively. Indeed, so great was the variety of work expected and demanded of the survey in connection with the economic resources of the State, that the amount of purely scientific work accomplished was thereby greatly limited.

Personnel.—The personnel of the survey for each fiscal year ending September 30 is given below. This list is believed to include the name of every individual who has been engaged upon the work. There were no regular or permanent assistants connected with the survey. Assistants were engaged from time to time by the geologist for special professional work or general office work as they were needed or could be secured. Some of these had only a nominal connection, others were connected with it at intervals during several years.

1866, W. C. Kerr, geologist; C. J. Curtis, assistant in topography; N. A. Pratt, assistant in chemistry. 1866–67, W. C. Kerr, geologist; William Cain, assistant in topography; N. A. Pratt, assistant in chemistry. 1867–68, W. C. Kerr, geologist; C. J. Curtis, assistant in topography. 1868–69, W. C. Kerr, geologist; E. D. Cope, assistant in invertebrate paleontology; G. B. Hanna, assistant in chemistry. 1869–70, W. C. Kerr, geologist; G. B. Hanna, assistant in chemistry; T. A. Conrad, assistant in invertebrate paleontology; G. C. Jordan, assistant in labeling cabinets. 1870–71, W. C. Kerr, geologist; William Cain, assistant in topography; T. A. Conrad, assistant in invertebrate paleontology: E. H. Bogardus, assistant in chemistry; G. B. Hanna, assistant in chemistry; C. F. Chandler, special assistant in chemistry; F. A. Genth, assistant in mineralogy. 1871–72, W. C. Kerr, geologist: William Cain, assistant in topography; G. B. Hanna, assistant in chemistry; E. H. Bogardus, assistant in chemistry; F. A. Genth, assistant in mineralogy; Mrs. C. P.

Spencer, assistant in office work; William D. Cooke, assistant in office work. 1872–73, W. C. Kerr, geologist; G. B. Hanna, assistant in chemistry; C. D. Smith, assistant in geology; William D. Cooke, assistant in office work. 1873–74, W. C. Kerr, geologist; C. D. Smith, assistant in geology; G. B. Hanna, assistant in chemistry; E. H. Bogardus, assistant in chemistry; William Cain, assistant in topography; William D. Cooke, assistant in office work. 1874–75, W. C. Kerr, geologist; A. A. Julien, assistant in lithology; G. B. Hanna, assistant in chemistry; William D. Cooke, assistant in office work. 1875–76, W. C. Kerr, geologist; A. A. Julien, assistant in lithology; J. B. Hanna, assistant in chemistry. 1876–77, W. C. Kerr, geologist; A. A. Julien, assistant in lithology; G. B. Hanna, assistant in chemistry and mining; A. R. Ledoux, chemist *ex officio*. 1877–78, W. C. Kerr, geologist; A. A. Julien, assistant in geology; A. R. Ledoux, chemist *ex officio;* William Cain, assistant in topography; T. C. Harris, curator of museum and assistant in engraving and general office work. 1878–79, W. C. Kerr, geologist; A. A. Julien, assistant in lithology; A. R. Ledoux, chemist *ex officio;* A. G. Williamson, assistant in topography; T. C. Harris, curator of museum and assistant in engraving and general office work. 1879–80, W. C. Kerr, geologist; A. A. Julien, assistant in lithology; F. A. Genth, assistant in mineralogy; A. R. Ledoux, chemist *ex officio;* William Cain, assistant in topography; A. G. Williamson, assistant in topography; T. C. Harris, curator of museum and assistant in engraving and general office work; R. G. Thomas, assistant in office work. 1880–81, W. C. Kerr, geologist; A. A. Julien, assistant in lithology; C. W. Dabney, chemist *ex officio;* T. C. Harris, curator of museum and assistant in engraving and general office work. 1881–82, W. C. Kerr, geologist; A. A. Julien, assistant in lithology; W. B. Phillips, assistant in geology; C. W. Dabney, jr., chemist *ex officio;* T. C. Harris, curator, etc.; W. H. Kerr, special assistant in geology. 1882–83, W. B. Phillips, acting geologist; A. A. Julien, assistant in lithology; C. W. Dabney, chemist *ex officio;* T. C. Harris, curator, etc.

The geologist of the survey was appointed by the governor, in accordance with the act of January, 1851, and subsequently in accordance with the act of 1879. The assistants employed by the survey were appointed by the geologist, subject to the approval of the governor, and no principles of promotion were laid down so far as the record shows.

Salaries.—The salary of the geologist was fixed at the time of his appointment in 1866 by agreement between the governor of the State and himself at $2,500 a year. By act of the general assembly, ratified February 20, 1879, it was enacted that after that date the compensation of the geologist should be fixed by the department of agriculture, and that it should not exceed $2,000 a year. As a rule the assistants on the survey were not paid regular salaries, but received such compensation for their work as was agreed upon between themselves and the geologist. No official record of the sum thus expended has been preserved.

In a few instances assistance was given without remuneration, as in the cases of Professors Conrad and Cope in working up the remains of fossil invertebrates and vertebrates collected by the survey. So far as can be learned, the geologist in charge of the survey was not paid a salary by any other institution during his connection with the survey.

With a few unimportant exceptions the assistants employed by the survey were connected with other institutions and gave only a portion of their time to the work. In such cases, so far as can be learned, they were paid salaries by the other institutions with which they were connected.

Methods in geological work.—In general geology, including here lithology and stratigraphy, concerning the methods adopted for the western region of the State the following extract is given from Professor Kerr's Report of Progress, 1866, pages 19 and 20:

> Since the general geological survey must necessarily serve as the basis and groundwork of the whole this comes first in order. It was necessary, therefore, in the beginning to take a bird's-eye view of the whole field of operations, to make a geological reconnoissance, in order to catch the outlines and leading features of the geological structure of the region to be studied, and thus to construct a skeleton or framework in which all the future details of the work would easily and intelligibly arrange themselves as they should be developed. This was necessary also in order to ascertain the character and amount of the work to be done, and to what points special effort and attention should be directed. This could be accomplished most speedily and satisfactorily by making a series of transverse sections across the upturned edges of the strata. In this State the direction of these edges, the strike, is almost universally from Northeast to Southwest, and this direction, being also that of the dominant mountain chain, the rivers in seeking the line of quickest descent, necessarily take a direction at right angles to the strike; and having worn for themselves deep channels through the strata, furnish extensive exposures of the rocks and so give the readiest means of obtaining the desired sections, although one is often obliged to use for this purpose the artificial and accidental exposures along the tracks of railroads, turnpikes, and even common roads.
>
> The Ocvee, Hiwassee, Cheowah, Nantehaleh, Tennessee, Tuckasege, Pigeon, and French Broad, with the Oconaluftee and Toxaway Rivers, furnished me as many sections, some of them partial, some of them completely across the breadth of the State. These sections enabled me to locate beyond the possibility of a doubt all the prominent geological features of the region and furnish data also for the construction of a geological map of that hitherto unknown country.

In all parts of the State where such advantages existed the geologist availed himself of the exposures along watercourses and railroads, and where these did not exist he traveled along country roads, usually in such directions as (in the middle and western regions of the State) to cross the upturned edges of the strata.

The mode of travel varied with circumstances. Along the line of railroads the geologist frequently made use of a handcar. In other cases he traveled by private conveyance along or near the line of railroad, making frequent excursions on foot for the purpose of examining the exposures of rock in the cuts. In hilly and mountainous regions, he traveled on horseback; along river courses, especially in the eastern section, he made use of boats when practicable, and was thus enabled the better to examine the exposures along the banks of the streams.

Of the lithological collections made, one set of specimens was deposited in the State museum, and a duplicate set (in part) was placed in the hands of the lithologist to the survey, Dr. A. A. Julien, of New York City, for further examination, with instructions that the specimens be carefully examined microscopically and chemically, if this latter also should prove to be necessary in determining their mineral composition and character. In addition, Doctor Julien himself, under the direction of the survey, examined in the field the crystalline rocks of the middle and western portions of the State, in order that he might the more intelligently prosecute his investigations in the laboratory.

With his own extensive examinations in the field of the character and stratigraphic relations of the crystalline rocks, and with the aid of Doctor Julien's investigations in the microscopic and chemical characters of these rocks, Professor Kerr hoped to solve, or at least to throw light upon, the problem as to the age of the crystalline rocks.

In connection with the topographic work, Professor Kerr brought together the records of the original surveys and triangulations of the United States Coast and Geodetic Survey, of Prof. Arnold Guyot, of the State geologist (himself), and of the United States Engineers; the surveys made by the State from 1820 to 1882 of swamp lands, railroads, rivers, canals, and turnpikes; the surveys of railroad, plank road, and other corporations to date; and numerous county and land surveys. The larger part of these were reduced to a common scale, the results redrawn and incorporated in the "Map of North Carolina."

Museum.—The collections of the survey deposited in the State museum consisted in 1887 of the following:

A collection of minerals and ores of between 6,000 and 7,000 specimens, in general so arranged as to illustrate the mineral wealth of the several counties of the State.

A collection of something more than 3,000 lithological specimens.

A collection of building stones, consisting of 100 specimens, varying in size from cubes 1 foot in diameter to smaller, taken from the quarries and other exposures of granite, gneiss, sandstone, marble, etc., in different parts of the State.

Soils and marls, upward of 200 specimens, from different portions of the State, collected primarily for analysis.

Woods, upward of 200 specimens, consisting of boards 2 feet long, 1 to 2 inches thick, and of varying widths, polished, illustrative of the native woods of the State.

Fossil shells, a collection of several thousand specimens, including a large number of species, mainly from the Cretaceous and Tertiary deposits of the eastern portion of the State.

Shells of forms now living—of marine, a small collection; of fresh-water and land shells, a small collection of each.

A few zoological specimens, including the skeleton of a whale (*Balaena mysticetus*), 65 feet long, porpoise, and a few smaller animals.

A small collection of agricultural products and of Indian antiquities.

Library.—The library of the survey contained in 1887 about 300 volumes, which include general and special treatises on general and applied geology, mineralogy, metallurgy, chemistry, agriculture, and general natural history, and the reports of the geological and natural history surveys of other States.

Expenses.—No records of the specific expenditures of the survey have been published or preserved in any way, so far as discovered. It may be stated, however, that the expenditure of the funds at the disposal of the survey ($5,000 a year) included the payment of salaries of officers and assistants, all the running expenses, and, at least, in part, the cost of engraving of maps accompanying the geological reports.

The annual expenditures of the survey from its organization in 1866 to October, 1882, the fiscal years ending September 30, is as follows:

1866	$3,000.00	1875–76	$6,000.00
1866–67	4,000.00	1876–77	5,000.00
1867–68	7,000.00	1877–78	4,000.00
1868–69	5,004.69	1878–79	[1] 3,246.62
1869–70	5,000.00	1879–80	4,786.00
1870–71	3,750.00	1880–81	3,671.27
1871–72	5,750.00	1881–82	4,314.84
1872–73	6,750.00	1882–83	546.61
1873–74	4,000.00		
1874–75	5,000.00		$80,820.03

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[1] Taken from report of department of agriculture, the auditor's report shows an expenditure of $1,870.

The geologist, as stated above, received no salary from other institutions than the survey. The chemist after 1877 was the chemist and director of the North Carolina experiment station and *ex officio* chemist to the geological survey. He was paid no salary by the survey, but as chemist and director of the station received an annual salary of $2,000 until 1885, when it was increased to $2,500.

The cost of engraving and printing connected with the reports of the survey was paid in part out of the funds of the survey, in part (prior to 1877) out of the public fund of the State, and in part (subsequent to 1877, when the department of agriculture, etc., was established) out of the funds of the department of agriculture.

Benefits.—As covering that period of the survey's existence from 1866 to 1875, the following is quoted from Professor Kerr:[1]

> The benefits of a geological survey have come to be recognized in all civilized communities. They are twofold, positive and negative. In this State they are seen in the discovery and development of mineral wealth—coal, iron, copper, etc.; in preventing or diminishing wasteful and ill-advised and ruinous enterprises. Several single mines of copper, of iron, and of coal, whose development is due to the operations of the survey, have brought into the State an amount of capital many times greater than the whole cost of the work. More than a million dollars, for example, has been invested in four or five such mines within the last three or four years, and only a beginning has been made. And I make no doubt that in the repression and prevention of mistaken adventures the pecuniary value of the work has been still more important. And many who live in the eastern section of the State will readily understand that the most important function of the survey is found in the direction of agriculture. The saving to the farmers of that section in one year in the matter of commercial fertilizers alone is counted by hundreds of thousands, without mentioning the direct benefits from the analysis of marls, peats, etc., and the extension and direction of their use.

Examined in the light of subsequent years the above statement concerning the benefits of the survey may be considered a fair one; and this notwithstanding the fact that a few of the mining investments in the State alluded to were unsuccessful. And in many ways the survey continued for nearly another decade to exert its beneficial effects.

In connection with the mining interests it has encouraged the introduction of capital into the State, and a more judicious investment of home capital. In a negative but important way it has been instrumental in preventing numerous investments where the undertaking would have proved a failure and the money invested lost.

In connection with the agricultural interests the beneficial results of the survey can not easily be estimated, but doubtless these have been considerable to the people in all sections of the State, and especially to those of the eastern and middle sections. Agriculture, during the entire existence of the survey, was regarded as an important field of work. Numerous analyses of marls, peats, and commercial fertilizers were made, and directions looking to the extension and use of these were widely disseminated. Many analyses of soils were made, and the people of the State were informed as to the methods of soil improvement.

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[1] Geology of North Carolina, 1875, p. xv.

From 1872 to 1877 the survey doubtless saved to the people of the eastern and middle regions of the State many thousands of dollars through its inspection of the commercial fertilizers sold and used in these regions; and in 1877 the State geologist was largely instrumental in the establishment and organization of the "department of agriculture, immigration, etc.," and the agricultural experiment station, which since that time has been of great value to the people of the State in regulating the manufacture and sale of commercial fertilizers, and in other ways.

Again, the survey has been of benefit to the people by advertising the natural resources of the State in this and in other countries. This has been done by making exhibits of specimens of minerals, ores, woods, etc., illustrative of the resources of the State, and through the published reports of the survey and official correspondence of the geologist with persons in our own and other countries. Such exhibits as referred to were made by the survey at the Vienna exhibition (1874), Philadelphia (1876), and Atlanta (1881).

The survey inaugurated the movement of a few years later looking to the increase in supply of food fishes in the streams of the State; and (as mentioned already) established and kept in existence for a time a series of meteorological stations in different portions of the State. It revived the silk-raising movement in North Carolina—a result of the visit of the geologist to the Vienna exposition. It measured the water power of all the important rivers of the State. It has left the public a fairly good knowledge of the physical features and climatology of North Carolina.

The educational feature should be kept in mind even when considering the material benefits resulting from the work of the survey. Through occasional public lectures by the State geologist at places in different portions of the State, through published reports, articles in newspapers, and private correspondence, the people of the different sections were informed, as far as was practicable under the circumstances, concerning the natural resources of their respective regions. Such information is of material benefit in that, on the one hand, it encourages investments in cases where there is reasonable ground for expecting success; and, on the other hand, where there is no such ground, the attention of persons interested is turned to some other undertaking, and loss of both time and capital is prevented.

Unfinished work of the survey.—Excepting the report on the minerals and mineral localities (ch. 1 of vol. 2 of Geology of North Carolina) brought out in 1881, the State map in 1882, and the report on the Ores of North Carolina (ch. 2 of vol. 2), published in 1887, none of the results of the work of this survey have been published since 1875.

After the death, in 1885, of Kerr, nothing more was done until 1891, when J. A. Holmes, of the State university, was appointed State geologist and continued to hold the office until 1904. No systematic work was carried on by this organization, which was occupied, as opportunity offered, in other consideration of special problems relating not only to geology, but timber resources and road construction as well. In 1905 a new act was passed establishing the present surveys.[1]

OHIO.[2]

The geological explorations of Ohio were begun in the interest of salt manufacture. The difficulty of securing this article, and the high price which it bore in the Ohio Valley all through the early years of the present century, seemed to the pioneers of this region the most serious obstacle to their success. All the salt that they used was brought across the Alleghanies on the backs of pack horses or up the Mississippi in flatboats. The price ranged from 8 to 16 cents a pound.

The early settlers, noting that certain springs of water slightly charged with salt were much frequented by animals, made in 1798 their first attempt at the home manufacture of salt at the "Old Scioto salt works." To prevent monopoly Congress, in 1808, reserved 6 miles square at this place for the use of the State and 1 square mile at each of the other two localities where salt springs were known to exist. These were the only places in the State at which this substance was found.

The first attempt at drilling for salt was made a few miles below Zanesville in 1817. Such was its success that many borings were made with varied results until, in 1826, the salt reservations were no longer considered necessary and the land was sold. Through ignorance of the formations much money was wasted by boring for salt where none could exist. The invariable presence of gas in salt wells was taken as a guide in new drillings. Boring was often begun where the presence of gas was noted, but all other indications of salt were absent.

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[1] See Bull. 465, U. S. Geol. Survey.

[2] Mainly from manuscript notes compiled by Miss D. M. Scott under the direction of Prof. Edward Orton.

It happened in the year 1819 that a certain physician interested in geology stopped at the house of a Mr. Chandler, the owner of a salt well in the Muskingum Valley. During the course of the evening the doctor asked about the character of the rock bored through. Mr. Chandler enumerated the rock formations, mentioning in particular one that was very hard, from which the pump brought up nodules of a very malleable metallic substance. The two searched about the well the next morning and found several pieces the size of wheat grains. Before the blowpipe they yielded silver of the purity of a Mexican dollar. A company was at once formed and incorporated by the Ohio legislature under the name of "The Muskingum Mining Co." For the privilege of working in a reserved section belonging to the State the company agreed to pay to the State treasury 15 per cent of all profits. Drilling was begun near the well where the metal had been found and was prosecuted with great difficulty owing to a constant influx of water. Silver, there was none, but the workmen drilled through a 7-foot seam of coal. As coal was not the object of search, its presence did not excite much notice at the time. At a depth of 140 feet they began to work laterally, extending the work to the salt well, which they carefully plugged. Their next attempt was to work up 15 feet to the horizon of the silver in the salt well. By some blow or concussion the plug was knocked out and the miners barely escaped. The company lost $11,000, expenses and damages for the ruin of the salt well. The work was abandoned and the shaft filled with rubbish.

Salt and iron industries were not all that attracted the attention of the people. In 1818 Caleb Atwater, of Circleville, provoked a discussion by an article on the Origin of the Prairies and Barrens of the West. From the depth of soil he inferred that the whole region was once under water, and that the outlet of the Great Lakes was through the Ohio. This brought forth various opinions as to the probable origin of prairies and barrens.

The *American Journal of Science and Arts* was the chosen medium for communication of facts and opinions of those interested in the resources of the State. Articles concerning the formations in different parts of the State, the useful products, and the industries are numerous. The finding of fossil bones, even those of human beings, is recorded; also that of vegetable impressions connected with the coal formations, and of fossil trees in the sandstone formations. The presence of the drift is noted and its southern boundary approximated. All the contributors of that day agree in ascribing its presence to water as the transporting agent.

In 1830 Judge Tappan contributed the discovery of cannel coal 1½ miles west of Cambridge, Guernsey County, near Grummon's

Tavern. It is described as a coal of very fine quality, especially noticeable for its high specific gravity (1.6), that being higher than the specific gravity of the English cannels or the American anthracites: exhibiting a conchoidal fracture and resinous luster, and burning with bright flame and less residuum than our common coals.

During the year 1831 the legislature chartered the Historical and Philosophical Society of Ohio. In an address delivered before this body by the Hon. Benjamin Tappan on December 22, 1832, he says:

> I am aware that a society like this, without funds and without many scientific associations of wealth and leisure, can not promise itself to obtain a geological survey of a whole or even of any very considerable part of the State in many years; but this society may commence the work, and when we shall have proved that we have at hand the necessary science to complete it we need not doubt but that Ohio will follow the example of Massachusetts and Tennessee and take under her munificent patronage the completion of the work.

By far the most valuable contributions to the *American Journal of Science and Arts* were from the pen of Dr. S. P. Hildreth, of Marietta. He was specially interested in geology, and was one of the best paleontologists in the State. From time to time he sent in communications with regard to the topography and geology of his own county and that of the valley of the Muskingum, giving detailed descriptions of the rock formations with sections. His contribution of 1836 excited widespread interest. An abstract of it is to be found in the *London and Edinburgh Philosophical Magazine.* The paper is the result of his observations on the bituminous coal deposits of the Ohio Valley and the accompanying strata. These observations extended over the southeastern part of the State of Ohio, southwestern Pennsylvania, and all of the valley of the Kanawha, covering a territory measured approximately by 5° longitude and 5° latitude. The topography of the county is minutely detailed; the geology given at length with illustrating sections; also the character, quality, and value of the limestones, sandstones, and clays; the location of coal beds and the quality of coal with the thickness of the seams; the character, quality, and mode of occurrence of iron ore; the depth of the rock salt, the general location of the wells, the density of the salt water, its analysis, and yield of salt; descriptions of the various fossils found, with accompanying plates; and notices of relics of ancient life, animal and vegetable.

Private interest was thus generally excited before the State, as such, evinced any concern. After the expenditure of a considerable sum of money, without return, in digging for coal at Cincinnati, silver in the Muskingum Valley and salt where none could be found, public interest was first manifested in the annual message of Gov. Robert Lucas, on December 8, 1835. The following is an extract:

I am impressed with the importance of calling the attention of the general assembly to the subject of the geological survey of the State. For want of a correct knowledge of the geology of the State large sums have been at various periods expended in useless searches after coal, iron, salt, gypsum, marble, and various other minerals. It is known that our country abounds in all the minerals above mentioned, with many others of great value. I would therefore respectfully submit to your consideration and solicit your inquiry into the importance of authorizing a general scientific geological survey of the State. Such a survey could not fail to furnish the State with a mass of information of the highest importance. Surveys of this character have been made under the State authorities in some of the Eastern States. Massachusetts has caused such a survey to be made, and obtained and published under her authority a scientific report of the geology, mineralogy, botany, and zoology of that entire State. * * *

I therefore respectfully solicit your inquiry into the expediency and utility of authorizing a general geological survey of the State, by a scientific, practical geologist to be employed by the State for that purpose, whose duty it should be to make an accurate and detailed report to the general assembly of his geological and mineralogical observations.

The house committee to which this portion of the governor's message was referred made through its chairman Mr. Creed the following report concurring in the opinion of the governor:

The subject is deserving of legislative action in that the survey will show the extent of deposits of useful products, it will reveal new localities and perhaps new minerals, thus causing great advancement in the industries of the State; it will reveal the probability of the existence of other valuable deposits beneath the surface of the earth in certain places; it will prevent useless waste of capital; it is of great importance to the agricultural industries of the State in revealing the nature and durability of the soils and their best fertilizers; it will diffuse correct information among all citizens, preventing the errors prevailing where no such examination has been made; it will acquaint every man not only with the agricultural value of his own soil but also with its hidden mineral wealth.

This survey will be greatly facilitated by the original survey of the territory by the General Government into small rectangular tracts which will enable the geologist without further horizontal admeasurements to make a map accurately designating the extent and limit of the various rock formations and the precise locality of every valuable mineral deposit. The extensive vertical admeasurements made by the canal engineers have shown the general elevation of the State above the sea and lake and the relative height of different parts. The committee append as evidence of the confidence which may be placed in the order of strata a report from England by Featherstonhaugh; also an essay on geology by Lapham, noting in particular the stratified appearance and regular order to be observed in rocks, and an extract from the address of the Hon. Judge Tappan before the Historical and Philosophical Society of Ohio relative to the importance of a correct knowledge of the composition of soils, durability of building stone, and to the importance of geological maps of every county correctly delineating the extent and quality of every rock formation, the location of mineral deposits and coal beds, and the number and thickness of such beds. The committee advise the appointment of one or two practical geologists by the general assembly to make a preliminary report to the next legislature.

A small appropriation will be necessary to meet their contingent expenses, or they may be paid from the governor's contingent fund.

A senate committe also considered this portion of the governor's message and reported a resolution through their chairman, Mr. Price, early in the following year (Mar. 14, 1836), appointing Samuel P. Hildreth, of Marietta; John Locke and John S. Riddell, of Cincinnati; and I. A. Lapham, of Columbus, to report to the next legislature the best method of obtaining a complete geological survey of the State, and an estimate of the probable cost of the same," which was agreed to, ordered to the house for concurrence, and passed by both branches the same day.

The following is the text of this resolution:

Appointing a committee to make certain geological observations and estimates of this State.

Resolved by the General Assembly of the State of Ohio, That Samuel P. Hildreth, of Marietta; John Locke and John L. Riddell, of Cincinnati; and I. A. Lapham, of Columbus, be, and they are hereby, appointed a committee to report to the next legislature the best method of obtaining a complete geological survey of the State, and an estimate of the probable cost of the same.

March 14, 1836.

The committee as above constituted made a lengthy report to Governor Lucas, who transmitted it to the house with his annual message. In communicating the report he expressed his entire concurrence in the views of the committee, earnestly recommended the adoption of the measures proposed, and gave it as his conviction that by constituting a geological board for the general survey of the State greater benefit would be conferred upon the State and the people than could be derived from an equal expenditure of money in any other enterprise.

"As to the best method of conducting the survey the committee advise that a geological board of three members be appointed, whose duty it shall be to direct the manner of procedure, employ suitable geologists, etc., with power to draw upon the treasurer for the annual appropriations for the purpose. Otherwise the board of public works may have charge of the survey.

"As to cost, $12,000 for four years would secure a regular scientific survey, requiring the service of one principal geologist, five assistants, one draftsman, and one naturalist. Their salaries, traveling and incidental expenses would amount to that sum. The survey, to be complete, ought to include not only geology but topography, botany, and zoology, and a regular survey and description of all ancient works by drawings and descriptions of all such as can be distinctly traced. The surveyors ought to make collections of all ancient relics to be placed in a cabinet in State library hall with specimens of all rocks, minerals, fossils, etc., in regular geological series not only for the State but a suite for each of the colleges. These will be of immense value to students of geology and mineralogy, to the miner and to the future historian of the State.

"Much more might be said, but this is sufficient to make the survey an object of deep importance to the welfare of the citizens. The increased value of real estate or the additional revenues from canals and railroads would in one year more than pay the cost of the survey. Several of the Eastern States are making such surveys with great profit to themselves. Let Ohio also engage in the work."

The expenses of the committee ($400) were met from the governor's contingent fund. Accompanying the message there was also a joint resolution on the subject of a geological survey of the State of Indiana, authorizing the governor of that State to correspond with the governors of Ohio and Kentucky relative to the survey of the territory of the three States, and to ascertain whether and upon what terms Ohio and Kentucky would join Indiana in that object.

So far as could be learned no action was ever taken upon this communication.

The general assembly ordered that 5,000 copies of the governor's message and accompanying documents be printed, also 5,000 extra copies of the report of the geological board. Three thousand copies of the message and accompanying documents were ordered printed in German. Within a few days it was ordered that 3,000 additional copies of that portion of the documents accompanying the governor's message that constitutes the report of the geological board be printed, 300 of which should be placed at the disposal of said board; 50 to be deposited in the State library; and the remainder to be distributed among the seminaries of the States with the accompanying maps and plates.

That portion of the report contributed by J. S. Riddell was not sent to the governor until March 9, 1837. This paper is relative to the limestone region of the State. The different limestones are described, the blue limestone and cliff limestone being especially emphasized. The report was read before the general assembly and 1,000 copies were ordered printed for their use.

Meanwhile the general assembly had entered earnestly upon the work, and after bills from both houses, resolutions, amendments, and counter amendments, finally passed on March 27, 1837, an act of which the following is a transcript:

An act providing for a geological survey of the State of Ohio, and other purposes.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio,* That the governor of this State is hereby requested, as speedily as may be, to cause a complete and detailed geological survey of the entire territory of this State to be made and executed, and a careful and accurate chemical examination and analysis of the various soils which may be found in different parts thereof, as also of the principal ores, marls, salines, and other mineral waters within the said State.

SEC. 2. That for the purpose of making such survey and analysis it shall be lawful for the said governor to employ a competent and skillful geologist, with two or more assistant geologists, if need be, provided said assistants do not exceed four in number; and may, if requisite, also engage the services of or employ a topographical surveyor, whose duty it shall be to make such observations and admeasurements as may be found necessary in the preparation and construction of the geological map of the State, hereinafter provided for, and to perform such other labors connected with the general purposes hereby intended as the geologist may from time (to time) prescribe and direct. In addition to the duties before mentioned to be performed the geologist who may be employed by virtue of this act shall also ascertain by accurate barometrical observations the height of the principal mountains in this State, and in the progress and examinations hereby directed shall collect and preserve all such specimens of rock, fossils, ores, mineral compounds, and organic remains as shall tend to exemplify the general geological structure of the State or be in anywise useful or interesting; the specimens, so far as practicable, may be collected in sufficient number to authorize the distribution of a suite thereof to the principal institutions of learning of this State, if it shall hereafter be found expedient to make such a distribution.

SEC. 3. That the said geologist shall annually and on or before the 1st day of February in each year (during the survey) make a full report to the governor of this State of his progress in the work hereby authorized and required, accompanying said reports with such profiles and maps, together with such a glossary of scientific or technical terms, as may be useful in illustrating the same, which reports, profiles, and maps it shall be the duty of the governor to lay before the general assembly.

SEC. 4. That for the purpose of defraying the expenses which may be incurred under this act a sum not exceeding $12,000 be, and is hereby, appropriated, to be employed in such manner as the governor shall deem advisable, to be paid on his certificate, out of any moneys in the treasury not otherwise appropriated, upon the warrant of the auditor of State.

SEC. 5. That when the entire work hereby contemplated and provided for shall have been fully completed it shall be the duty of the geologist in charge thereof to make a general and final report thereon, embracing in the said required report the result of all the surveys, examinations, and discoveries which shall have been made, whether geological, chemical, topographical, or otherwise, together with all other matters connected therewith which may be considered by him as likely to be in any manner useful to the public or interesting to science. He shall also construct and prepare for engraving a complete geological map of this State, showing not only the general geological structure thereof, but plainly and accurately delineating the stratification of its principal rocks and position and boundary of all the mineral deposits which may be now known or be hereafter ascertained by the investigations which shall have been made, accompanying the said map with such a series of sections or profiles as may be necessary to a proper exhibition of the geology of the region to which they may relate. The final report, together with the map and the accompanying sections and profiles, shall be communicated by the governor to the general assembly as soon as may be, to be printed, engraved, published, and disposed of in such manner as to the said general assembly shall seem proper.

SEC. 6. That the mineral materials and other specimens which may be collected during the operations of the geologist and others who may be engaged with him shall be carefully preserved in some convenient apartment under the care of the librarian until otherwise provided for. A complete catalogue of such specimens and materials shall be made out by said geologist and preserved in the same apartment, showing the name, locality, general properties, and value of each as ascertained by the analysis to which it may have been subjected, and referring to the corresponding number which shall be affixed to the specimen itself.

March 27, 1837.

Subsequently the following resolutions were passed bearing upon publications and the disposition of survey property:

Resolved by the General Assembly of the State of Ohio, That Samuel Medary be authorized to procure the engraving and printing of such diagrams, maps, and profiles as may be necessary to illustrate the reports on the geological survey of the State, and the copperplate shall, after use, be deposited in the geological survey office.

January 10, 1838.

Resolved by the general assembly, That all books, papers, instruments, apparatus, and collections of any kind and description whatever now in the possession of the members of the late geological corps of the State and belonging to the State be deposited for safe-keeping with the Ohio Historical Society, and that the same shall remain in the possession of said society until called for by the State.

March 18, 1839.

FIRST SURVEY UNDER WILLIAM W. MATHER, 1837–1839.

Administration.—In his annual message on December 5, 1837, Governor Vance reported that, in compliance with the foregoing act, he had appointed W. W. Mather, of New York, as principal geologist, and Doctors Hildreth, Kirtland, and Locke, of Ohio, and Professor Briggs, of New York, as assistants, and Charles Whittlesey, of Ohio, topographical surveyor and draftsman. In the absence of Doctor Locke his place had been supplied by Mr. Foster, who had been in active duty with Professor Briggs in making examinations of the southern portions of the State. Owing to previous engagements the chief had been unable to give his entire attention to the survey, but had directed the assistants and purchased such apparatus, etc., as would enable the corps to prosecute the work during the next season with vigor and effect. The governor wished Doctors Hildreth and Kirtland to take charge of the survey, but they declined the honor, and it was upon their advice that he had appointed Doctor Mather. Both gentlemen, however, continued in the service of the State until December 30, when Doctor Hildreth retired because of ill health.

The delay in organizing the first geological corps was great, and its members did not begin field work until the summer of 1837 was half over. What was accomplished during the year was mainly in the way of reconnoissance and in preparation for more efficient work during the coming season.

January 17, 1838, Governor Vance received the first annual report of the geological corps and transmitted the same to the general assembly. By resolution it was agreed that 5,000 copies should be printed for the use of the general assembly, and that 1,000 be put into the hands of the geologists for distribution to scientific societies and gentlemen in various parts of the country; and that 1,000 copies extra of the geological queries, which have for their object to elicit the local knowledge of individuals, be published for distribution to the people by the geologists when engaged in field duty.

The report is a small octavo volume of 134 pages. with map and sections. It embraces reports of Doctors Mather, Hildreth. and Kirtland, Professor Briggs, and Colonel Whittlesey; geological queries addressed to those interested; a glossary of terms used; and a table of contents. The report reflects great credit upon the corps, shadowing forth as a beginning the greater results to come.

The work of the year was limited to the eastern and southeastern parts of the State, and extended but little beyond the coal measures at any point. To accomplish the work rapidly and efficiently, distinct departments were created. Doctor Hildreth had charge of the paleontological department; Doctor Kirtland, of the Ohio Medical College at Cincinnati, of botany and zoology; Professor Briggs and Mr. Foster of the field work between the Scioto and Hockhocking Rivers; Colonel Whittlesey of the topographical department.

To facilitate the progress of the survey certain querries were propounded to the people of the State, with the hope that every one interested would contribute such aid as lay within his power, inasmuch as the local knowledge of individuals may expedite the work of the board.

In the early part of the year 1838 a resolution was passed requiring the geological board to report to the house whether any member of the corps had purchased land in consequence of information derived from examinations made under State authority; also whether others had located such lands upon their advice, with the amount and location of these lands in each case. Doctor Mather replied that 700 acres in the aggregate had been purchased. He himself had become owner of 500 acres in Jackson County, as a residence, but its mineral resources had not been developed by the survey so far as known. Furthermore, when anything of value was found upon land, it had been the policy of the board to communicate the fact to the owners.

Expenses.—The expenses of the survey during the year 1837 amounted to $2,089.57. The financial panic of that year induced the State legislators to advocate retrenchment. Such an enterprise as the survey was certain to be one of the first objects to which an appropriation would be denied, and the appropriation for the work of the year 1838 failed. In consequence there existed a rumor that the survey would not be continued. Work was resumed, however, on the unexpended balance of the first appropriation, although it was insufficient to keep the entire working force in the field. The expenses for the year 1838 aggregated $9,648.80. The corps worked well, but was much restricted in efficiency for want of means.

On December 4, 1838, Governor Vance reported that the appropriation for the support of the geological corps before the last assembly had failed; that a portion of the force had been kept at work by the unexpended balance of the former appropriation; and urged the importance of continuing the work in accordance with the original design.

The chairman of the committee to whom this portion of the governor's message was referred strongly advised that the work be continued, inasmuch as the action of the legislature in authorizing the survey had met with the approbation of the citizens generally and results had been obtained which would justify its completion. The expenses were necessarily greater for the first years of the survey than they would be when the work was well underway. The work scarcely begun would, if carried on develop additional treasures and greatly improve the agricultural interests of the State. All would tend to expedite the sale of the public domain and extend the list of taxable lands. The report closed with a resolution to the effect that the survey be continued and that an appropriation of $12,000 be made for that purpose. The matter was tabled.

Shortly after, Governor Shannon transmitted to the general assembly the Second Annual Report of the Geological Survey. This was uniform with the first report and contains 274 pages. The board consisted of W. W. Mather, principal geologist, and Charles Whittlesey, Col. J. W. Foster, C. Briggs, jr., J. P. Kirtland, and John Locke, his assistants.

As complaints had been preferred that the former year's work of the survey benefited only the coal and iron region, the work was extended beyond that portion of the State, revealing useful materials for the arts and for building, but from lack of easy and inexpensive transportation it was doubtful whether these would ever become of more than local value.

The average expense of the survey of each county had thus far been about $1,000, while the benefit resulting to a single one of these, arising from the increased valuation of real estate incident to the developments of mineral wealth, was estimated to be at least $100,000, and by some as $500,000. So it was with other counties as their resources were made known and were appreciated.

Although the matter of continuing the survey was of such grave importance to the best interests of the State, a change of political control was allowed to interrupt the work, and as time passed the chance of resuming it seemed to grow more and more distant.

The legislature ordered that 5.000 copies of the report of the geological board be printed. For payment of arrearages for services of the corps and for procuring engravings a sum not exceeding $4,000 was appropriated by law March 18. 1839.

The legislature directed that all books, papers, instruments, apparatus, and collections of any kind in possession of the members of the late corps be deposited with the Ohio Historical Society for safekeeping, there to remain until called for by the State.

By act of the legislature in March, 1841, there was appropriated for paying the expenses of labeling and arranging specimens collected by the geological board, and distributing such portions as were intended by law for the literary institutions of this State, a sum not exceeding $300, to be expended under the direction of the governor.

Governor Corwin, in his message of December 7, 1841, reported that the collections resulting from the survey had remained until a late day without classication; that in view of the small appropriation made during the last session for labeling and arranging specimens for preservation here. and for distribution to the literary institutions of the State, he had procured the services of W. W. Mather, whose work would be completed by January 1, 1842; and he earnestly recommends a continuance of the survey on a limited and economical scale especially in reference to the agricultural interest.

> If by the labors of a geologist so appointed 1 bushel of wheat to the acre extra should be raised it would pay the salary of such an officer twice told for many years to come.

Collections.—Early in 1842 Doctor Mather reported to Governor Corwin that the specimens, nine suites in all, were labeled. Two suites were reserved for the State; the rest were boxed and ready for distribution. One suite belonging to the State was arranged by counties, and, being duly catalogued, was on exhibition in glazed cases. The other suite was still in boxes from lack of cases. A different arrangement was contemplated. To arrange them in a manner uniform with the other specimens would require an expenditure of from $120 to $150 for cases, and three or four weeks' labor. After reporting that many specimens had been brought in for analysis, he added that a geological office might be kept open, analyses made, and the survey be continued on a moderate scale at a cost of $3,000 a year, including all expenses.

In 1844 an attempt was made by Governor Bartley to revive the interest of the legislature in the survey, recommending that the work be allowed to progress on a limited scale. Nothing was done in the premises. For a decade all that was accomplished was in the nature of private enterprise.

A resolution of 1845 authorized Colonel Mather to take charge of the chemical apparatus belonging to the State until the next meeting of the general assembly, on condition that he give assurances to the governor for the safe return of the same at the time specified.

The resolution (March 18, 1839) giving the historical society control of the effects of the former geological corps was rescinded in 1852. All was then placed under control of the Ohio State Board of Agriculture subject to the order of the legislature.

After this several attempts were made by the legislature to have the survey resume work. Some little attention was given to the subject in 1851, and in 1854 a great effort was made by the house to pass a bill for its continuance. The committee to which the house bill was referred made a lengthy report through Chairman J. H. L. Scott, urging the importance of a thorough and efficient geological survey as a means of insuring the advancement of the pecuniary interests of the State, the advancement and perfecting of science, agriculture, and the full and proper development of its rich mineral resources. The example of other States was cited, and the advantages reaped from the former survey, incomplete as it was, were demonstrated. The relation of the sciences to agriculture was pointed out, and the agricultural importance of the survey particularly dwelt upon. The bill, besides providing liberally for the geological survey, provided for the establishment of an agricultural college. The house thought best to postpone the matter until 1856. At that time the subject was revived in another bill from Dr. M. Jewett, which had the misfortune to be postponed until the following year.

Meantime a committee was appointed to report as to the condition of the papers, documents, etc., belonging to the first survey, and the probable cost of compiling and procuring the publication of facts then ascertained, together with an estimate of the expense of completing the work. The committee reported the progress made during the survey, that valuable articles of Dr. S. P. Hildreth were to be found in Silliman's *Journal*, and that in the possession of private individuals and corporations were many valuable articles, the product of private explorations and observations, which would be of great value if properly brought before the public, but would not do justice to many portions of the State. Taking into consideration the desirability of continuing the survey and the probability that such a publication would only postpone it, the committee reported against it and recommended the early continuation of the survey. In the same year the senate committee to which the matter had been referred, reported the bill of Mr. Canfield, which, after a great deal of discussion, was ordered to lie on the table.

Gov. S. P. Chase, in his annual message of 1857, in view of the valuable results of the former survey, respectfully submitted to the consideration of the general assembly the questions, "whether the time has not arrived for the resumption of that work, and whether there should not be combined with it such an agricultural examination as will fully ascertain and disclose the productive capacity of the different soils which compose the surface of the State, and the physical laws and influences by which that productive capacity is determined." In accordance with this recommendation a bill was introduced in the house by Mr. M. Jewett and reported upon by committee. The bill was lost upon its final passage.

In 1860 Governor Chase asked in connection with furthering the agricultural interest, "May I not add that the resumption and completion of the geological survey of the State, with special reference to agriculture and mining, could not fail to benefit all interests connected with the soil?"

Governor Dennison, in his inaugural of the same year, said:

> Every other State in the Union except Florida has completed or has in progress a geological survey of her territory, and I would recommend to your early consideration the completion of the geological survey of this State, which has been too long suspended. I doubt not its importance to the agricultural and mining interests of the State and to the advancement of science will fully justify an appropriation for its vigorous prosecution.

Although the survey was so persistently advocated by the governors, notwithstanding the fact that the legislature had been for years receiving petitions from citizens in various parts of the State praying that the survey be continued, and although the receipt of 15 such petitions is recorded in the journals of 1860 alone, yet the legislature did nothing conclusive during that year. A bill to provide for the continuation of the survey was introduced in the senate by James A. Garfield, only to be postponed until the following year. The senate committee on the geological survey was requested "to ascertain, if possible, the entire cost of the geological surveys of New York, including all printing and all other incidental expense connected therewith, also the cost which has been hitherto incurred by Ohio in such surveys, including printing and other incidental expenses, and report the same as early as practicable to the senate."

It is not recorded that the committee ever made a full report as requested.

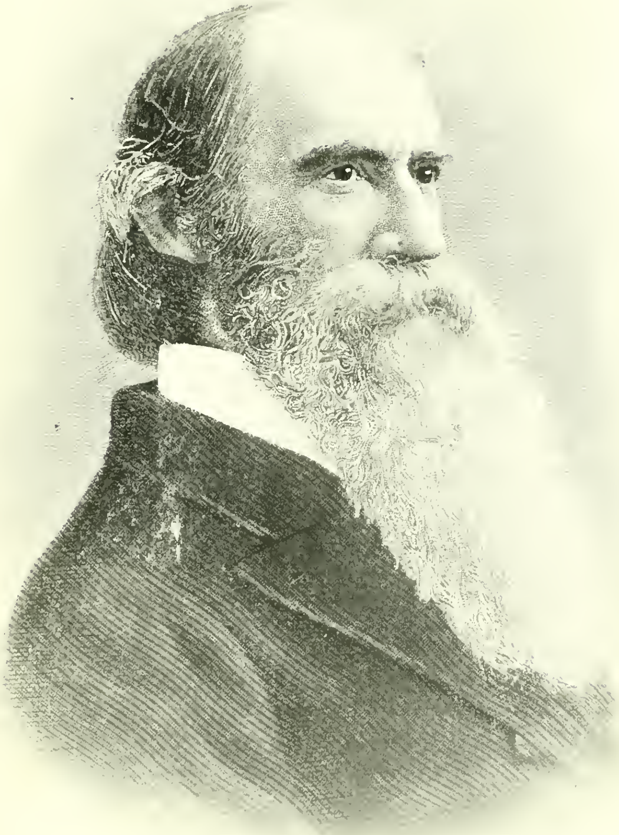
The committee to which had been referred that portion of the governor's message of 1860 relating to the survey made an elaborate report through Chairman Garfield. The events leading to the establishment of the geological corps were detailed and a brief sketch of the work done was embodied. Reference was made to the benefits of the survey through that most powerful medium—statistics. For the eight counties most thoroughly explored by the corps the value of taxable lands was given for the years 1835 and 1841; that is, before and after the survey:

	1835	1841		1835	1841
Jackson	$61,391	$196,795	Scioto	$658,212	$811,629
Meigs	135,558	373,358	Coshocton	730,071	3,733,784
Muskingum	1,921,474	2,966,111	Athens	282,948	867,322
Hocking	102,684	226,664			
Clermont	1,614,023	2,197,618	Total	$5,506,361	$11,373,281

Thus, in so short a time the increase was greater than 100 per cent, while the entire outlay upon the survey amounted to about $25,000. So great an increase of wealth from such a small outlay, was certainly a most powerful argument for the continuation of the survey. The report was esteemed of sufficient value to justify the printing of 1,000 extra copies for the use of the general assembly.

SECOND GEOLOGICAL SURVEY UNDER NEWBERRY AND ORTON, 1869–1886.

The whole matter of a geological survey of Ohio was dropped until the year 1865, the attention of the legislature being given to matters more pressing in their nature. The subject was then resumed by the senate in a bill to provide for the appointment of a State geologist. The committee reported the bill back with one amendment. The amendment annulled the bill and provided for the resumption of the survey. This was, in turn, amended in such a way as to annul it, and provision was made for the establishment of a geological bureau in connection with the State board of agriculture, the secretary of the board to be State geologist ex officio; for the appointment by the county commissioners of one practical geologist in each county to make a survey of that county, expenses to be paid from



JOHN STRONG NEWBERRY

STATE GEOLOGIST OF OHIO, 1869 84.

the county treasury. As an alternative, several counties might join hands in the work, all to make annual reports to the State geologist. The bill as amended passed the senate, but the attempt to make the geological survey of the State of Ohio other than a State matter was deservedly frustrated by the refusal of the house to accede to this bill "to provide for the appointment of a State and county geologist."

From financial considerations no attempt was made to renew the effort to have the survey recommenced until 1868. Then Gov. J. D. Cox, in his annual message, advised the completion of the survey of the State in detail, "showing not simply the large general features which are already pretty well known, but the minutest facts of its geological and natural history," feeling sure that the citizens would be amply repaid by resources developed and by the attraction of desirable newcomers. Added to that, a horticultural society had called attention to the necessity of a full investigation into the nature and habits of certain injurious insects, representing reasonably enough that such investigation could not be undertaken by individuals, but that public advantages required that it be done at public cost.

> As part of the complete survey of the geology and natural history of the State the topic is worthy of your attention, and I am persuaded that such a work carefully performed would be a most profitable investment of the cost by encouragement and assistance which would be thereby rendered to the great producing interests of the State.

This portion of the governor's message was by resolution referred to a select committee of the house. The committee reported by bill which, after its second readings, was referred to the committee on finance. That committee reported by a joint resolution authorizing the governor to inquire into the practicability of securing the services of a competent and skillful geologist for the purpose of making a geological survey of Ohio. The bill, report of committee, and resolution were referred to the committee on judiciary and there engulfed.

During the 30 years that had now elapsed since the suspension of the first survey the resources of the State had been slowly developing. Investigations into the geology and economic value of certain districts of the State were entirely the work of private parties, and as such lacked the unity essential to rapid progress. Without doubt more money was expended during this interval upon surveys of mining properties, analyses of coal, iron, etc., made at private cost, than would have sufficed to complete the first survey. Information gained from private experience was monopolized by those who paid for it. Instead of being used to inform the landowner as to the mineral wealth underlying his possessions, such knowledge was made subservient to the speculator and enabled him to buy up such land at a nominal price based upon its agricultural value. Experience proved that no farmer would have the mineral wealth of his property investigated at his own cost. Capitalists invested their wealth in other States whose resources were better known.

For 20 years the legislature had thoroughly appreciated and constantly kept in view the advantages which would certainly accrue from the work, and had had many admonitions of the necessity of completing it from the different governors; but every bill had been defeated for one reason or another, usually a financial one. The poorest economy that could be practiced was that which strangled the best interests of the State while trying with rare shortsightedness to further them.

It was thought that no better method could be found to fill the State treasury depleted by the war expenses than by developing the long-neglected resources of the State. Accordingly Gov. R. B. Hayes in his annual message of November 23, 1868, wrote:

> I submit to your consideration the importance of providing for a thorough and comprehensive geological survey of the State. Many years ago a partial survey was prosecuted under many difficulties and embarrassments, which was fruitful of valuable results. It is beyond doubt such that a work as it is now practicable to carry out will by making known the mining, manufacturing, and agricultural resources of the State lead to their development to an extent which will within a few years amply reimburse the State for its cost.

A resolution was offered by Capt. Alfred E. Lee, member from Delaware County, to refer this portion of the message to a committee of five.

A short glance at the political situation will reveal what chance there was for enacting any measure to promote the survey. The governor was Republican, the legislature Democratic. The committee had to face these considerations, and to work against 20 years of constant failure, although the cause had been championed by such men as Doctor Jewett and General Garfield. Chairman Lee corresponded with many influential people throughout the State, but received no encouragement. Col. Charles Whittlesey, E. B. Andrews, J. H. Klippart, and others all agreed as to the importance of the survey and to the impossibility of successfully introducing any measure to complete it. Nevertheless, Captain Lee drafted a bill which he presented with the report of the committee.

The report set forth the advantages reaped from the former survey, meager as it was, the benefits derived by other States from their surveys in attracting capital and a good class of immigrants, and the fact that in addition to losing a share of such benefits, the best citizens were constantly emigrating to the fertile lands of the West.

> As the various geological reports have been extensively used by our Government agents and railroad men in negotiating foreign loans, and are carefully

consulted abroad by those who wish to invest their capital or fix their homes in America; and, furthermore, as these reports are considered the only authentic and thoroughly reliable exposition of the agricultural and mineral resources of a particular section, it is easy to see how important it is that Ohio, one of the first States of the Union, should no longer delay in giving to the world adequate scientific information of the vast elements of wealth that lie treasured in her bosom.

There is, furthermore, a scientific necessity for this in the fact that the elaborate surveys of New York and Pennsylvania in the East and Kentucky, Michigan, Illinois, and other Western States make Ohio a needed keystone in the geological arch, an invaluable member, without which the symmetry and connection of the whole can never be obtained.

The practical advantages to agriculture and mining, the interests which "underlie all others and constitute the groundwork of our prosperity," were thoroughly emphasized.

Ohio's rapid growth in population and its sequence—the increasing reduction in her agricultural export—create an additional necessity from year to year for the development of her mining and manufacturing interests. By this means a better home market will be provided for the products of her soil, while at the same time there will come with new sources of wealth new demands for labor which would give employment for any surplus population. The agricultural resources of Ohio, great as they are, scarcely equal those which lie beneath her surface and which promise an exhaustive field to her genius, labor, and capital.

To a new and complete survey of Ohio the old partial one would serve a valuable purpose as a preliminary reconnoissance, while at the same time the labors of the geological corps would be greatly facilitated by the elaborate surveys of adjacent States. These considerations should be taken into account in estimating the cost of a new survey.

The cost of one or two other State surveys was given, together with some estimates of the survey of Ohio. In conclusion:

From the best information they can gather your committee believe that a good survey of Ohio can be completed on the plan presented within three years at an expense, including that of publishing reports, of not exceeding $50,000.

The importance of the report procured the printing of 500 additional copies for the use of the members.

Accompanying the report was a bill providing for the survey. Inasmuch as it supplied the missing keystone, it is given in full:

An act providing for a geological survey of Ohio.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio,* That the governor is hereby required to appoint, by and with the advice and consent of the senate, a chief geologist, who shall be a person of known integrity and competent, practical, and scientific knowledge of the sciences of geology and mineralogy; and upon consultation with said chief geologist, and the like concurrence of the senate, the governor shall appoint one or more suitable assistants, not exceeding three in number, one of whom shall be a skillful analytical and agricultural chemist; the said chief geologist and assistants to constitute a geological corps, whose duty it shall be to make a complete and thorough geological, agricultural, and mineralogical survey of each and every county in the State.

Sec. 2. The said survey shall have for its objects:

1. An examination of the geological structure of the State, including the dip, magnitude, number, order, and relative position of the several strata, their richness in coals, clays, ores, mineral waters and manures, building stone, and other useful materials, the value of such materials for economical purposes, and their accessibility for mining or manufacture.

2. An accurate chemical analysis and classification of the various soils of the State, with the view of discovering the best means of preserving and improving their fertility, and of pointing out the most beneficial and profitable modes of cultivation. Also a careful analysis of the different ores, rocks, peats, marls, clays, salines, and all mineral waters within the State.

3. To ascertain by meteorological observations the local causes which produce variations of climate in the different sections of the State. Also to determine by strict barometrical observations the relative elevation and depression of the different parts of the State.

Sec. 3. It shall be the duty of the said chief geologist, in the progress of the examination hereby directed, to collect such specimens of rocks, ores, soils, fossils, organic remains, and mineral compounds as will exemplify the geology, mineralogy, and agronomy of the State, and shall deposit said specimens, accurately labeled and classified, in a room provided by the State board of agriculture, to be carefully preserved under the supervision of said board.

Sec. 4. It shall be the duty of the chief geologist on or before the first Monday in January of each year during the time occupied in said survey to make a report to the governor of the results and progress of the survey, accompanied by such maps, profiles, and drawings as may be necessary to exemplify the same, which reports the governor shall lay before the general assembly.

Sec. 5. When the said survey shall be fully completed the chief geologist shall make to the governor a final report, including the results of the entire survey, accompanied by such drawings and topographical maps as may be necessary to illustrate the same, and by a single geological map showing by colors and other appropriate means the stratification of the rocks, the character of the soil, the localities of the beds of mineral deposits, and the character and extent of the different geological formations.

Sec. 6. The annual appropriations which may be made by the general assembly for carrying out the provisions of this act shall be expended, under the direction of the governor, upon the certificate of the chief geologist, approved by the governor, and the warrant of the auditor of State, as follows: For salary of chief geologist, $3,000; for salaries of assistants, not more than $1,800 each; for chemicals, $500; for contingent expenses of the survey, including actual traveling expenses of geological corps and hire of local assistants, $500.

Sec. 7. No money shall be paid for the purposes of said survey until the chief geologist and his assistants shall have entered upon the discharge of their duties as prescribed by this act.

Sec. 8. The survey shall be commenced by the 1st of June next, or as soon thereafter as practicable, and shall be completed within three years from and after the time of its commencement.

Sec. 9. This act shall take effect and be in force from and after its passage.

The bill as read was ably supported by Messrs. Lee and Lewton of the committee and by Mr. Leete, the Democratic member from

Ironton. So forcibly was its passage urged, so great was the interest created in its favor, that party lines were ignored. The bill passed the house by a handsome majority, was referred to the senate, was passed by that body without amendment, and became a law on April 3, 1869.

The matter of publication and distribution of the reports was provided for by the following:

Joint resolution relative to printing the Annual Report of the Geological Corps of Ohio for the year 1869.

Whereas the engraving of the plates, which accompany the geological report, will delay the publication of that report for several months, and there are some portions of the report that should be given to the public at as early a date as possible: Therefore

Resolved by the General Assembly of the State of Ohio, That so much of Professor Newberry's report as will serve to form a report of progress of the geological survey of Ohio for 1869; Professor Andrews's report on the geology of southeastern Ohio; Professor Orton's report on the geology of Montgomery County, with such maps and sections as are prepared to illustrate each of these reports, be printed at once in pamphlet form as the annual report of the geological corps of Ohio for the year 1869, to the number of 2,500 copies; 500 copies for the geological corps and 2,000 copies for the general assembly, to be divided equally among the members, and sent by the secretary of state as provided for the distribution of the agricultural report to the auditor of each county of each member as soon as printed; and that the publication of the remainder of the manuscripts submitted by the geological corps be deferred until the plates shall be engraved.

Adopted April 14, 1870.

Three years later the bill of 1869 was supplemented by the following:

An act to complete the geological survey of the State of Ohio.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio*, That the governor, State school commissioner, and the treasurer of State are hereby constituted a geological board, whose duty it shall be to exercise supervision and control of the geological survey of the State.

SEC. 2. It shall be the duty of the said geological board to ascertain the nature and extent of the work already performed under the present law providing for a geological survey of the State, which expires May 31, 1872, and to determine the best methods of securing a thorough and scientific completion of the survey.

SEC. 3. The geological board shall have power to assign all unfinished work of the survey to a geological corps consisting of a chief geologist and two assistant geologists, men of capacity and geological knowledge, to which number shall be added a chemist of approved skill, which persons shall be appointed by the governor, by and with the advice and consent of the senate, their appointments to take effect on the 1st day of June, 1872.

SEC. 4. The geological board shall have power to make such a division of the territory of the State between the several geologists as shall secure the most thorough and harmonious investigation of the geology of the whole State, including its minerals, soils, and fossils.

SEC. 5. It shall be the duty of the geological board to direct, in regard to all expenditures of money which may be appropriated by the legislature for carrying on said survey, and to secure an equitable apportionment of such money to the several districts of the State; also to determine the number of assistants to be employed by the geologist and the chemist and the amount of their compensation.

SEC. 6. The geological board, after an immediate investigation of the work of the present geological corps, already reported on and published by the State, shall direct in regard to the preparation of all other and future reports, and recommend to the legislature for publication the reports thus prepared.

SEC. 7. The geological board shall see that the minerals, soils, and fossils of the State collected during the survey be properly classified and labeled by the geologist or such paleontologists as may be employed, and give to the Agricultural and Mechanical College of Ohio, and duplicates, as far as practicable, to each other college in the State authorized by its charter to confer degrees and possessing a geological department and employing a professor of geology.

SEC. 8. The geological board shall require that all maps, drawings, sections, notebooks, reports or partial reports, records and data, and materials of whatever kind not yet incorporated in reports already published which have accumulated in the hands of the present geological corps and their local assistants; also all minerals and fossils of every kind which have been gathered by the corps and assistants, be delivered to the said geological board by the members of said corps on or before the 31st day of May, 1872.

SEC. 9. The annual appropriations which may be made by the legislature for carrying out the provisions of this act shall be drawn from the treasury upon the certificates of the several geologists and chemists, approved by the governor and the warrant of the auditor, as follows: For the salary of the chief geologist, $2,500; of the assistant geologist, $2,000; for the salary of the chemist, $1,500; and for the contingent, including the traveling expenses of the geological corps and assistants, the pay of the assistants; and the cost of the needed chemicals and apparatus, $5,000.

SEC. 10. This act shall take effect from and after its passage and continue in force until the 1st day of June, 1873.

Passed April 29, 1872.

Administration.—In accordance with the act of 1869 the governor appointed John S. Newberry chief geologist and E. B. Andrews, Edward Orton, and John H. Klippart assistant geologists. These nominations were afterward confirmed by the senate. In addition the following-named persons were employed as local assistants: Rev. H. Hertzer, M. C. Read, Frederick Prime, jr., W. P. Ballantine, G. K. Gilbert, Andrew Sherwood, R. D. Irving, W. A. Hooker, W. B. Potter, Henry Newton, and H. A. Whiting. Rev. H. Hertzer was paid from the chief's salary as compensation for the reason that his time was but partially devoted to the work. Messrs. Read, Prime, and Ballantine received small salaries during the working season, while the rest of the gentlemen served for their expenses. The corps organized and was ready for work by June 1. Mr. Klippart, for many years secretary of the State board of agriculture, had charge of the agricultural department, and Prof. T. G. Wormley, one of the ablest analytical chemists in the country, of the purely chemical work.

To gain a general knowledge of the geological system of the State the field was divided into four districts, cornering at Columbus. Professor Newberry had immediate supervision of the work in the northeastern quarter, Professor Andrews the southeastern, Professor Orton the southwestern, and Messrs. Hertzer and Gilbert the northwestern. It was the aim of the corps to perform the work so thoroughly that it would never be necessary to go over the ground a second time. To this end explicit directions were given each member for making observations and collections.

Expenses for 1869.—The disbursements to the account of the geological survey for the year 1869 amounted to $8,066.01.

Publication of First Annual Report.—Early in the year 1870 the senate received a message from Governor Hays transmitting the first annual report (second series) on the geology of Ohio, with accompanying letter of J. S. Newberry; also a message transmitting a letter from Prof. E. B. Andrews in relation to the coal fields extending from the vicinity of Nelsonville, Athens County, to the northeast through the southern part of Perry County.

The committee on public printing, to whom was referred the Report of the Geological Corps for 1869, recommended the adoption of the following joint resolution:

> Whereas the engraving of plates which accompany the geological report will delay the publication of that report several months, and there are some portions of the report that should be given to the public at as early a day as possible, be it
>
> *Resolved by the general assembly*, That so much of Professor Newberry's report as will serve to form a report of progress of the geological survey of Ohio for 1869; Professor Andrews's report of the geology of southeastern Ohio; Professor Orton's report of the geology of Montgomery County, with such maps and sections as are prepared to illustrate each of these reports, be printed at once, in pamphlet form as the annual report of the geological corps of Ohio for the year 1869 to the number of 2,500 copies; 500 copies for the geological corps and 2,000 copies for the general assembly, to be divided equally among the members and sent to the auditor for the county of each member as soon as printed; and that the publication of the remainder of the manuscripts be deferred until the plates be engraved.

This was adopted and became a law April 14, 1870. In compliance with the resolution the portions of the report mentioned were embodied for immediate publication.

A resolution was shortly proposed by a member of the house directing the supervisor of public printing to procure the printing of the report of 1869, in the best style, in pica type, in large octavo form, on heavy white or tinted paper, and bound in muslin. This resolution did not come up for final passage. The supervisor, acting upon the supposition that it had, proceeded with the work as it directed. It was therefore found necessary to push the resolution through early in the next session, with the saving clause, however, that nothing in the resolution should be construed to direct "any other or further printing than the edition of said report hitherto caused by said supervisor to be printed and bound in muslin under the supposition that this resolution had been passed at the first session of the general assembly."

Within three weeks from the settlement of this question by law another joint resolution was adopted to procure the printing, binding, and distribution of 10,000 copies additional of the report of 1869, and 2,000 copies in German, with the same illustrations as the English edition; 50 copies for the governor, 50 for the Ohio State library, and the remainder for the use of the general assembly. It was afterwards voted that 300 copies be placed at the disposal of the corps—100 to the chief and 50 each to the four next in rank.

In 1870 the house adopted a resolution instructing the committee on retrenchment to inquire into the expenditures of the survey and to investigate everything connected with it, empowering that committee to send for persons and papers, and requiring a report at as early a day as possible. The committee was not heard from until the following year, when both majority and minority reports were sent in. The majority report criticized the appointment of T. G. Wormley as chemist, when the law specified that one of the assistants should be a "skillful agricultural and analytical chemist."

After giving the sum total of all expenses of the corps, the committee recommended that the State be divided into three districts, each one to be in charge of those best fitted for the work, implying undivided personal attention, and that a competent chemist be centrally located; each of the four appointees to receive $2,000 a year. Then followed the replies of Colonel Whittlesey, E. B. Andrews, and Leo Lesquereux, as to the purpose of the survey, the best method of conducting it, whether the existing appropriations were adequate, etc., from which it is possible to gather much interesting information. The minority report recommended that the work be continued under the corps as organized in accordance with the plan pursued to date.

Museum.—A law of 1870 imposed upon the chief geologist the duty of collecting a full set of specimens for the benefit of the Ohio Agricultural and Mechanical College, then in its infancy.

Expense during 1870.—During the same year an appropriation of $17,250 was made for continuing the survey, itemized as follows: Salaries of chief and three assistants, not exceeding $5,950; contingent expenses, $11,300, of which $1,500 was specially appropriated for chemicals and apparatus. For the year 1870 the disbursements amounted to $19,815.80 for salaries, chemicals, traveling, and other expenses.

Governor Hayes, in his annual message of 1871, called attention to the fact that the future wealth and population of the State would depend largely upon the mining and manufacturing interests. While not questioning the benefits to accrue to agriculture from the survey, he emphasized the truth that the tendency was to encourage the employment of labor and capital in mining and manufacturing enterprises, and recommended that the work be continued and sustained by ample appropriations. In response an appropriation of $20,900 was made later in the session.

Publication of Second Annual Report.—The annual report of 1870 was transmitted to the general assembly March, 1871. The governor reported that he had been advised that the first volume of the final report was nearly ready for publication and would be sent to the legislature during that session. He suggested that measures be immediately taken for printing it.

By joint resolution it was decided that the report for 1870, by J. S. Newberry, chief, including reports of E. B. Andrews, Edward Orton, and J. H. Klippart, assistants; T. G. Wormley, chemist; and G. K. Gilbert, M. C. Read, Henry Newton, and W. B. Potter, local assistants, be printed at once as the annual report for 1870, in the same form and style as the annual report of 1869, to the number of 2,500 copies; and provision was made for their distribution.

The character of the work, replete with statistics as it was, did not gain for it the wide popularity the report of 1869 had enjoyed. For the same reason its greater intrinsic worth can not be questioned. Two thousand copies of this report were ordered printed in German.

No pains was spared to secure the proper distribution of the report. The supervisor of public printing was directed to deliver to the governor 150 copies for distribution to the American, English, French, and German magazines and papers devoted to mining and science; to the principal libraries of the United States, England, France, and Germany; and to the libraries of each State and Territory. Further, the librarian of the Ohio State library was required to accommodate inquiries for the work from literary institutions, historical societies, colleges, and similar organizations from 200 copies granted for the purpose. One thousand copies of the report were lost in some manner, and measures were taken to prevent the recurrence of such loss.

Work of 1871.—Throughout the year 1871 the work of the corps progressed rapidly and satisfactorily. Quite a number of additions was made to the local working force, several of these being unpaid volunteers. Four parties were constantly in the field engaged mainly on county surveys. By the close of the season about three-fourths of the area of the State had been examined in detail.

A sketch of the progress of the survey during the year was made to the legislature of 1872. This is a pamphlet of eight pages consisting of a business report of progress and prospects of the survey. It was made brief that its publication might be immediate and that it might become the basis for legislative action. The preceding annual reports had failed to meet the demand of the legislature for fresh information through the necessary delay caused by printing, etc. The publication of such voluminous annual reports greatly delayed the final report and it was decided not to continue the practice.

Expenses during 1871.—The disbursements for salaries and contingent expenses for the year amounted to $21,843.19.

Renewal act of 1872.—The time originally specified for the completion of the survey having expired, leaving the work far from complete, there was passed, April 29, 1872, the act to complete the survey, a transcript of which is given on pages 405–6. By this act the governor, school commissioner, and treasurer were constituted a geological board to exercise supervision and control. Their duties were to ascertain the nature and extent of the work already performed under the present law; to determine the best method for securing a thorough and scientific completion of the survey; to make a division of territory and assign work to be done by the corps; to direct the expenditure of money for geological purposes; to determine the number of assistants to each geologist and the chemist, and the compensation of the same; to investigate the work of the present corps already reported and published; to give directions for the preparation of future reports for publication; and to provide for the preservation and distribution of all specimens collected; all maps and drawings to be delivered to the board before the first of June following; corps to consist of a chief, two assistants, and a chemist; the governor to appoint members of the corps, with advice and consent of the senate; appointment to take effect June 1, 1872. Salaries: Chief, $2,500; assistants, $2,000; chemist, $1,500; other expenses, $5,000. The manner of drawing appropriations was also specified by law.

The act was to continue in force for one year. The same day provision was made for publishing 20,000 copies of the first volume of the final report, with illustrating maps, plates, and sections, for printing it in best style, on good paper, royal octavo, for binding in muslin, and for distributing the work when finished. Two thousand copies were ordered printed in German. The chief geologist believed that an edition of 5,000 copies would be adequate to meet all demands, but inasmuch as the reports of 1869 and 1870 had been so eagerly taken up the legislature made provision for a larger edition.

This work had previously been transmitted to the senate by Governor Noyes, together with letters from Professor Henry, of the Smithsonian Institution, and F. B. Meek, paleontologist with the United States Survey of the Western Territories; also a communication from Hon. James A. Garfield, recommending the necessary measures to be adopted for the printing of volume 1.

Administration.—In obedience to the provisions of the act of April 29 the governor, recognizing the expediency of continuing the survey under the existing corps so far as practicable, appointed J. S. Newberry, chief; E. B. Andrews and Edward Orton, assistants, and T. G. Wormley, chemist.

In the annual message of January 2, 1873, Gov. Edward F. Noyes made the following report and recommendations regarding the survey:

> The geological survey of the State has progressed satisfactorily during the past year. The first volume of the final report is now in the hands of the printer and will be ready for distribution at the present session of the general assembly. Material for another volume is now nearly ready, and it is hoped provision will be made for its early publication. To perfect the work of the survey according to the original design and in harmony with what has already been completed will require one year more, and it is recommended that the time of the geological corps be extended accordingly, and that such appropriation be made therefor as may be necessary.
>
> Five maps upon a somewhat extended scale have been prepared by Professor Andrews, representing the coal region in the district assigned to him. The funds heretofore appropriated for engraving and printing were not sufficient to warrant the board of control in ordering as many copies of these maps as there will be volumes in the edition to be published. If it should be considered desirable that an equal number should be printed an additional appropriation will be required.
>
> The geological survey is a very important work in an economic point of view, to say nothing of its scientific interest. It has already added largely to the value of real property in the State, while its developments and disclosures are inviting labor and capital from abroad. To make a satisfactory and creditable survey necessarily consumes considerable time and costs large sums of money. It is, however, believed that our work is being well and faithfully done, and at the same time more expeditiously and cheaper than similar work has ever been performed in other States.
>
> You are requested to provide for the necessities of the survey by such appropriations as careful estimates shall call for and your judgment shall approve.

Provision was made for paying for the flyleaves of volume 1 and the paper used in printing the second part of the volume from the appropriation for stationery and blank books. It had been the intention to print the final report upon finer and larger paper than was used for other State printing. Such provision was indeed made, but it was found that no one had been authorized to make the purchase. Before the legislature convened again part 1 had been completed. As soon as that body met it thus authorized the purchase of the finer paper in time for the printing of part 2. It has always been a matter of regret to all that the books are not uniform in size and quality of workmanship.

Appropriations for 1872–1874.—In accordance with the recommendation of the governor the time when the act of 1872 should continue in force was extended until February 15, 1874, by which time the survey was to be completed. An appropriation of $20,214.17 was made for continuing the work.

Publication of volume 1 of final report.—During the year the long-expected volume 1 of the final report made its appearance. This is in two parts, known as parts 1 and 2, or as volume 1, Geology, and volume 2, Paleontology.

Volume 1, Geology, consists of 680 pages. Section 1 treats of the general geological relations and structure of Ohio. Section 2 deals with local geology. Section 1 embraces a brief history of the survey up to the date of the final report, the physical geography of the State, the geological relations of the Ohio series, the structure in detail, including mention of the more important fossils of each great formation. The section on local geology includes reports of the geology of 23 counties described by townships, with geological maps of 13 of the number, besides a paper on the surface geology of the Maumee Valley with map, a report of the geology of the West Sister Island, and an important report of the geology of the Cincinnati group, by Edward Orton, with map and tables of fossils of the group. Appendix A contains 10 tables of temperature and rainfall at various points. Appendix B gives the profiles of all of the most important railroad and canal lines. There is only a partial list of the railroad profiles given.

Volume 1, Paleontology, or part 2 of the final report, is the first illustrated memoir ever published on the fossils of the State. It is printed on larger and heavier paper than part 1 and contains 399 pages and 48 fine lithographic plates as illustrations. The Ohio series is of such great range that there are few finer fields for paleontological work in the world. To produce such a creditable work as part 2 it was necessary to employ specialists. By the work of the paleontologist many of the vexed questions in regard to the Ohio series were settled. The knowledge gathered from the fossils was of inestimable service in the acquisition of the information conveyed in the geological reports. Section 1 of the volume, the work of F. B. Meek, is a description of the invertebrate fossils of the Silurian and Devonian systems. The descriptions of fossil fishes and of the fossil plants of the coal measures contained in sections 2 and 3 are the work of J. S. Newberry.

The field work of the corps continued throughout the season of 1873.

Publication of Third Annual Report and volume 2 of the final report.—The annual message of 1874 announced that the field work of the survey had been completed, and a large amount of material collected for future volumes. With the utmost industry it was found impossible to finish the text for publication. Material for two volumes would be ready by the expiration of the time for which the geological corps was appointed. Inasmuch as the original plan contemplated two additional volumes—one on economic geology and the other devoted to zoology, botany, and agriculture, and as a general geological map should accompany the printed volumes, two years more time at an expense of $10,000 a year would be required to complete the whole in a commendable manner. The governor therefore recommended that an appropriation be made for the immediate publication of two volumes, and that $10,000 be added for the continuation of the work another year, and urged that in view of its importance and the widespread commendation it had elicited, it would be an unwarrantable waste of time and money if the material already prepared should not be utilized.

The general assembly responded by appropriating $60,000 for the publication of volume 2 of the Final Report and $1,000 for deficiencies in the salaries. That body further gave control of all maps, plates, and charts used in any report of the survey to the secretary of state. At the same time the fossils and minerals in charge of the State librarian were handed over to the Ohio Agricultural and Mechanical College.

Provision was made for the publication of 20,000 copies of volume 2, with all accompanying maps, plates, and sections, and for the distribution of the work. The number of copies to be printed in German was left to be decided by those concerned in the distribution of the volumes. Care was taken that the mistakes of the first volume should not be repeated. The secretary of state was empowered to purchase good paper, but when it was delivered it was found to be far inferior to the samples and was rejected. The authorities had to choose between a delay of several months and the use of the inferior paper for part 1 on geology. They chose the latter course. The result is that part 1 of volume 2 is uniform in size and style with part 1 of volume 1, while part 2 of both volumes correspond in style and in size.

Expenses.—The expenses of the survey during 1874 were $16,976.14.

Publication of volume 3 of final report.—In the year 1875 an appropriation of $7,000 was made for preparing volume 3, Geology, for publication under the direction of the former chief geologist, J. S. Newberry; and for printing, binding, and publishing 20,000 copies of the same, an additional appropriation of $15,000 was made. Provision was also made for distribution, but as some time elapsed before the volume was given to the printer, the law was rescinded. The disbursements for 1875 were $37,276.75, the whole amount being paid for preparating and printing volume 2. In 1876 an additional appropriation of $2,784.49 was found necessary for paying the expenses of volume 2. The entire cost of the survey during the year was $23,201.22.

Progress during 1877.—In January, 1877, Governor Hayes reported that the first part of volume 3 was going through the press, the second part nearly complete, and the material for the other two volumes contemplated in the original plan were almost ready. It had been thought advisable to add to the general geological map of the State, detailed maps of the most important mining districts on so large a scale as to admit of the clear representation of all mines, mining properties, furnaces, and rolling mills. As no provision had been made for the work beyond volume 3, Geology, be recommended another appropriation.

The great delay in publishing this volume was due to work of revision, the preparation of a review of the geological structure of the State, and the work on the geological map and six maps of the mining districts.

Expenditures during 1877.—The appropriation of the year was $2,500. The expenditures, mainly for volume 3, were $8,199.52.

The general assembly finally provided for "the printing, binding, and distribution of 20,000 copies of the book in 1878, in order that the present assembly might enjoy that honor."

Volume 3 is uniform in size with both the other volumes on geology, and contains 958 pages. This volume completed the series on geology. No provision was made for the publication of part 2 of the volume, and the paleontological series was thus left incomplete.

Appropriations for 1878.—For the year 1878 the sum of $22,400 was appropriated for the survey; $11,750 for the publication of map to accompany volume 3 of the survey; $2,000 to complete volume 3, part 2, Paleontology; $650 to prepare reports for publication; and $8,000 for publishing 20,000 copies of volume 4, Zoology and Botany.

Proceedings during 1879.—The beginning of the year 1879 is marked by a call from Governor Bishop for legislative investigation into the cause for the delay in finishing the work originally contemplated by the survey, alleging that additional appropriations were continually called for while the expense already far exceeded the original estimate. The matter was referred to the committee on the geological survey. Both majority and minority reports were forthcoming on the last day of the session. The majority regarded the course pursued with high disfavor, and complained that too great prominence had been given to paleontology. The minority held a contrary opinion.

Governor Bishop's next annual message condemned the practice of the legislature in voting large editions, maintaining that the money could have been much better expended on field work, and urged the resumption of field work with a view to the development of the economic features of the State.

Expenditures in 1879.—The appropriation for 1879 was but $2,800, while the expenses were $12,463.34.

Publication of atlas.—In 1880 provision was made for the distribution of the edition of 5,000 copies of the geological atlas printed. For work on the survey no appropriation was made that year, though a bill was introduced providing for a more complete survey.

Expenditures during 1880.—The expenses amounted to $7,448.39.

The next year Governor Foster invited the attention of the legislators to the unfinished publications of the survey. The copy for the second part of volume 3 was by that time ready for the printer. The time and mode of publication were in the hands of the legislature. The plates for illustration, necessarily expensive, and the large edition needed to match the part already published, would require a large appropriation. The volume on natural history, volume 4, of the series required by law was reported in the hands of the printer, while volume 5, economic geology, justly viewed as the most important member of the series, was still forthcoming. As the bill for a more complete survey of the State, with special reference to economic features, which was before the legislature the last session, did not reach a vote, the sentiment regarding it was not yet formally expressed:

> In view of the probability that this measure will be further urged during the present session, I bespeak your careful consideration of the subject involved. It is beyond dispute that the last survey has done a great deal for the development of the mineral wealth of the State. Its publications have been eagerly sought for at home and abroad, and its official and uncolored testimony has encouraged the investment of large amounts of capital from within and from without the State in our coals and ores. But, on the other hand, it is equally beyond dispute that the reports as they now stand are incomplete and inadequate for almost every district of the State. They have been rendered so in part by the very development which they have fostered. The 10 years that have passed since many of these mineral belts were explored have been marked by much activity and enterprise. The knowledge of the field has been greatly increased, so much so that the statements of the reports are no longer valuable as guides to exploration in many cases. There is also a widespread conviction that a greater degree of certainty in regard to the continuity and character of our mineral deposits is attainable than we now possess.

> If, in view of such considerations, you shall decide to continue in some form the work of the survey, it will be possible for you to avail yourselves of a large amount of experience, both in this and neighboring States, as to dangers to be avoided and advantages to be gained.

Publication of volume 4 of final report.—The delay in the publication of volume 4 became a subject for legislative investigation. From the report made by its editor, Dr. J. M. Wheaton, it was found that the delay resulted from press of other State printing, lack of paper, etc., and that if the work was uninterrupted, it might be finished in six months. An appropriation (lapsed) amounting to $2,894.96 was consequently restored; $1,143.53 was expended upon the volume during the year.

The following year provision was made for the speedy binding and distribution of the long-delayed addition to the series. The work as it stands is uniform with the volumes on geology and numbers 1,020 pages. It is wholly devoted to zoology, and includes a report on the Mammals of Ohio, by Prof. A. M. Brayton; Birds, by Dr. J. M. Wheaton; Reptiles and Amphibians, by Dr. W. H. Smith; and Fishes, by Dr. David S. Jordan. The report is full and complete and abundantly compensates for its delay. The report on Mollusks by Dr. R. M. Byrnes, and the catalogue of the plants of the State would have increased the volume to undesirable dimensions, so they were left to form, with such additions as might be made to the material already prepared, a second part to the volume. It was hoped that by the preparations on economic botany and economic entomology which ought to be included, a second part of great practical value might be added in a short time.

Professor Newberry in his preface writes:

> Some impatience has been expressed at the slow progress of the preparation of the volume on zoology and botany, and the late appearance of the part now issued. But it should be remembered that all time and thought which have been expended on these thorough and voluminous reports destined to be so creditable and useful to the State have been gratuitously bestowed. Not a dollar has been paid to the authors for the years they have spent in this work, and justice as well as courtesy demands that the invaluable gifts now made to the people of Ohio by the eminent naturalists who have prepared these reports should be gratefully acknowledged. Probably nowhere in the history of scientific publication can be found more honorable examples of the gratuitous consecration of time and learning by men of science to the higher interests of the public.

The value and importance of the volume are rendered greater since, with the exception of isolated newspaper and magazine articles, nothing had been published in regard to the zoology of the State since the catalogue prepared by Dr. J. P. Kirtland and issued with the second annual report (first series) in 1838. No compensation was ever voted to the authors of volume 4; that still remains one of the great unrecorded State debts.

In view of the delay of the volume on economic geology, which ought to have been expected as no appropriation had ever been made for its publication, although it had been repeatedly requested, a bill was introduced early in the session of 1882 to provide for the completion of volume 5, Geology of Ohio. The act became a law April 17, 1882. The following is the wording of this act and a supplementary act of April 19, 1883:

To provide for the completion of volume 5. Geology of Ohio.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio,* That the governor is hereby required to appoint, by and with the advice and consent of the senate, a competent geologist, whose duty it shall be to revise and prepare for publication the materials already accumulated for a volume on the economic geology of Ohio by the chief of the recent State geological survey and designated in the schedule of reports of said survey as "Geology of Ohio," volume 5. It shall further be the duty of said geologist to supplement and extend the investigations already made as to the order of arrangement, extent, composition, and useful applications of the leading mineral products of the State, and especially of the economic products of the coal measures, so that said volume shall contain at the date of its issue an accurate statement of the general facts as to those subjects so far as known.

SEC. 2. The said geologist shall have power to employ assistants, who shall work under his direction in the investigation of the several subjects to be reported upon.

SEC. 3. The said geologist shall receive while in the actual discharge of his duties a monthly salary of $200, to be paid upon vouchers signed by the governor, and the assistants shall receive monthly salaries, in no case to exceed $120, to be paid upon vouchers signed by the governor and the geologist in charge.

SEC. 4. All necessary traveling and incidental expenses incurred by the geologist and his assistants in the prosecution of their work shall be paid from the treasury of the State upon vouchers signed by the governor and the geologist in charge.

SEC. 5. The said geologist shall enter upon his work as soon after his appointment as practicable, and shall complete the revision and preparation of the volume by or before the first Monday of March, 1883.

SEC. 6. There is hereby appropriated from the general revenue fund a sum of $5,000 that may be used for the purpose named above, but no money shall be drawn from the treasury until the work shall have been entered upon.

This act shall be in force from and after its passage.

Passed April 17, 1882.

An act supplementary to "An act to provide for the completion of volume 5, Geology of Ohio," passed April 17, 1882.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio,* That the time for the completion, revision, and preparation of volume 5, Geology of Ohio, provided for in the act to which this is supplementary, be extended to September 16, 1883, and it shall be the duty of the chief geologist, after the completion of said volume, to superintend the printing and proof reading of the same.

Sec. 2. There shall be printed of said volume 5, under the contract for said printing, 10,000 copies, including maps and illustrations, as shall be directed by the chief geologist, and these copies shall be bound in the same style as the volumes of the series already published.

Sec. 3. Of the copies of volume 5 that are published the following distribution shall be made, viz: To the State library, 500 copies; to the chief geologist and his assistants, 200 copies; to each State officer and to each State institution, 1 copy; to be deposited with the secretary of state, to be sold at the cost of publication, under such regulations as he may establish, 1,000 copies; the remainder to be equally divided among the members of the sixty-fifth general assembly.

Sec. 4. For the completion of the field and chemical work of the survey, for the revision and preparation of the manuscript for said volume 5, for the engraving and printing of suitable maps and illustrations, and for superintending the publication and proof reading of said volume there is hereby appropriated from the general revenue fund the sum of $9,500; for paper, the sum of $2,600; for printing, the sum of $1.200; and for binding, the sum of $2,000.

Sec. 5. Upon the publication of said volume 5 the geological survey of Ohio is hereby declared to be completed.

Sec. 6. This act shall take effect on its passage.

Passed April 19, 1883.

This act was supplemented in 1884 by the following:

Supplementary to an act passed April 19, 1883, entitled "An act supplementary to 'An act to provide for the completion of volume 5, Geology of Ohio,' passed April 17, 1882" (O. L., vol. 80, pp. 199 and 200).

Section 1. *Be it enacted by the General Assembly of the State of Ohio,* That the appropriation made "for the completion of the field and chemical work of the survey, for the revision and preparation of the manuscript of said volume 5, for the engraving and printing of suitable maps and illustrations, and for superintending the publication and proof reading of said volume," shall also be available for the purchase of paper and in payment for printing, in addition to what has already been appropriated for these several purposes, specifying as the needs of said volume may require.

Sec. 2. The State geologist is hereby instructed to use, as far as practicable, any and all balances remaining from the several appropriations above named in the publication of such descriptions and figures of fossils as have been already prepared for publication at the expense of the State, and to include said descriptions and figures in said volume 5.

Sec. 3. This act shall take effect and be in force from and after its passage.

Passed March 18, 1884.

This act was in turn amended, as follows:

To amend an act entitled "An act supplementary to 'An act to provide for the completion of volume 5, Geology of Ohio,' passed April 17, 1882," passed April 19, 1883 (O. L., vol. 80, pp. 199 and 200).

Section 1. *Be it enacted by the General Assembly of the State of Ohio,* That section 3 of the above-recited act be amended so as to read as follows:

Section 3. Of the copies of volume 5 that are published the following distribution shall be made, viz: To the State library, 500 copies, to be used in

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exchange with public libraries of other States, and to be furnished to public libraries of this State; a sufficient number to be retained for the use of the State library, and the remainder, if any, to be sold at the cost of publication, under the direction of the commissioners of the library; to the chief geologist and his assistants, 200 copies; to each State officer and to each State institution, 1 copy; to be deposited with the secretary of state, to be sold at cost of publication, under such regulations as he may establish, 1,000 copies; the remainder to be equally divided among the members of the sixty-sixth general assembly.

Sec. 2. That said original section 3 of the act supplementary be, and the same is hereby, repealed.

Sec. 3. This act shall take effect and be in force from and after its passage.

Passed March 15, 1884.

Administration.—In compliance with the provisions of the act of 1882 Gov. Charles Foster appointed Edward Orton State geologist. The work was at once entered upon and vigorously pushed, but it proved to be a task of such magnitude that it was found necessary to ask for an extension of time. The $5,000 appropriation was thought sufficient for the year's work. The expenses on the two volumes, 4 and 5, aggregated $5,171.92.

The act of April 19, 1883, extended the time for completing volume 5 to the 1st of September and required the State geologist to superintend its printing and proof reading. The number of copies was fixed at 10,000 and uniform with the rest of the series, and provision was made for their distribution. A new feature in the proviso was the item, "1,000 copies to be deposited with the secretary of state and sold at cost of publication." An appropriation of $15.300 was made for completing the field and chemical work, revising and preparing the manuscript, engraving and printing suitable maps and illustrations, superintending the publication, and proof reading, and for paper, printing, and binding volume 5. On publication of this volume the survey was declared complete.

The legislature provided for the smaller edition and for the sale of a small portion of it upon the advice of the State geologist. The work was completed and prepared for the printer with all possible speed, so that the volume was issued during the year 1884. The expenses for 1883 were $8,377.95.

Provision had been made for distribution to the members of the sixty-fifth general assembly. The sixty-sixth assembly proved itself unwilling to see the experiment of selling a portion of the books at cost ($1.02 a volume) thoroughly tried. Early in the year 1885 a joint resolution was passed giving the 800 copies remaining unsold to the members, thus disappointing those who would have been glad to avail themselves of the opportunity to make their series complete.

From lack of time to prepare, much valuable matter was omitted in regard to the coals, only those of the lower measures having been noted.

and in regard to lime production, cement manufacture, the production of gypsum, salt, bromine, petroleum, and inflammable gas.

No appropriation was made for the work during the year 1884. The expenses were $8,754.16. By a law previously enacted the sum of $10,000 was placed to the credit of the survey.

On the issue of this volume it was at once seen that the continuance of the work in this field was an object to be desired. Accordingly, Governor Hoadley reported that much material still remained in possession of the State geologist, consisting in the discussion of the upper coal measures, cements, limestones, salt, petroleum, and gas wells of the State. It was thought that with six months' further field work sufficient material for another volume would be at hand, since the accidental discovery of gas wells in Wood County and elsewhere indicated that "the knowledge of our resources was still far from complete."

As a result there was enacted a law which required the governor to appoint a geologist whose duty it should be to extend and complete the account of economic geology begun in volume 5, treating in particular those portions of the Ohio coal fields not yet reported upon, also salt and bromine, the composition, structure, strength, and durability of the building stones of the State, the production of lime, natural cements, marls, and land plaster, and all other substances produced in the State that come under the head of economic geology; empowered the geologist to employ assistants; fixed the salaries and provided for contingents; required the geologist to enter upon his duties as soon as practicable and fixed one year as the limit for the whole work; appropriated $4,500 for all purposes; and provided that the chapter on inflammable gas should be prepared for publication in advance of the rest of the volume, and that the copy be delivered to the supervisor of public printing by October 1, 1885.

The following is the full text of this act, and its supplement, passed a month later:

An act to provide for the extension of the geological survey of Ohio.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio,* That the governor is hereby required to appoint, by and with the advice and consent of the senate, a competent geologist, whose duty it shall be to extend and complete the account of the economic geology of the State that is begun in volume 5, Geology of Ohio. He shall treat, in particular, of those portions of the Ohio coal fields that have not yet been reported upon; of the production of petroleum and inflammable gas in the State, and also of salt and bromine; the composition, structure, strength, and durability of the various building stones of the State; of the production of lime, natural cements, marls, and land plaster; and of all other substances produced in the State that come under the head of economic geology.

SEC. 2. The said geologist shall have power to employ assistants, who shall work under his direction in the investigation of the several subjects to be reported upon.

SEC. 3. The said geologist shall receive, while in the actual discharge of his duties, a monthly salary of $200, to be paid upon vouchers signed by the governor, and the assistants shall receive monthly salaries, in no case to exceed $125, to be paid upon vouchers signed by the governor and the chief geologist.

SEC. 4. All necessary traveling and incidental expenses incurred by the geologist and his assistants in the prosecution of this work shall be paid from the State treasury upon vouchers signed by the governor and the chief geologist.

SEC. 5. The said geologist shall enter upon his work as soon after his appointment as practicable.

SEC. 6. The chapter on petroleum and inflammable gas shall be prepared for publication in advance of the volume to which it belongs, and copy for the same shall be delivered by the State geologist to the supervisor of public printing on or before the 1st day of October, 1885; then shall be printed 2,500 copies of this chapter under the contract for State printing, but the paper, maps, and illustrations shall be provided by the State geologist from the appropriation hereinafter named; the distribution of the copies published shall be made upon the same basis as that by which volume 5, Geology of Ohio, was distributed, except that 500 copies shall be left with the secretary of state to be sold at cost of publication.

SEC. 7. The said geologist shall enter upon his work as soon after his appointment as practicable, but said work shall be completed within a year.

SEC. 8. There is hereby appropriated from the general revenue fund the sum of $4,500, that may be used for the several purposes named above, but no money shall be drawn from the treasury until the work of the survey shall have been entered upon.

SEC. 9. This act shall take effect and be in force from and after its passage.

Passed May 1, 1885.

An act supplementary to an act entitled "An act to provide for the extension of the geological survey of Ohio," passed May 1, 1885.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio,* That the time for the preparation and completion of the second volume of the economic geology of Ohio is hereby extended to February 1, 1887, at which date the State geologist shall furnish to the governor for the lgislature, the manuscript, maps, and illustrations for said volume in proper form for publication, and sufficient to make a volume of the same size and general character as the other volumes of the geological survey report, and when published shall be termed "Economic Geology No. 6." The volume shall treat in particular of those portions of the Ohio coal field that were not reported on in volume 5; of the production of petroleum and inflammable gas in the State; of salt and bromine; of the composition, structure, strength, and durability of the various building stones of the State; of the production of lime, natural cements, and land plaster; and of other substances produced in the State that come under the head of economic geology.

SEC. 2. In place of the chapter on petroleum and natural gas, which was to be presented for publication October 1, 1885, the State geologist shall furnish to the supervisor of public printing, on or before June 15, 1886, an abstract of the results of his investigations on these subjects during the last year, of which abstract there shall be printed under the contract for State printing 2,500 copies, but the paper, maps, and illustrations for said abstract shall be provided by the State geologist from the appropriation made on May 1, 1885. A statement of the results of the chemical work of the survey for the last year may also be appended to this abstract. Of the 2,500 copies of said abstract printed there shall be made the following distribution: To the State library, 50 copies; to the State geologist, 150 copies; the remainder to be equally divided among the members of the sixty-seventh general assembly.

SEC. 3. The further work of the survey shall be prosecuted under the system and by the regulations established in the act to which this is supplementary.

SEC. 4. There is hereby appropriated from the general revenue fund $3,000 for the purposes named above.

SEC. 5. This act shall take effect and be in force on and after its passage.

Passed May 17, 1886.

Under these acts Professor Orton was again appointed State geologist, and work promptly begun on volume 6 of the reports.

Governor Hoadley in the message of 1886, advised the continuance of the survey as part of the duties of the professor of geology in the State university in order that great profit might accrue from small expenditure. He reported the material for volume 6 as nearly ready but that the geologist advised that it be issued in parts, and that the publication of the volume complete be deferred until the year following.

The time was therefore extended until February 1, 1887, by act of the general assembly; already given (p. 421). In place of the chapter on petroleum and natural gas, which was to have been furnished October 1, 1885, the geologist was required to furnish by June 15, 1886, an abstract of the results of his investigations on these subjects during the year; provision was made for the printing and distribution of 2,500 copies of the abstract; the law established that the survey be prosecuted under the provisions of the law of May 1, 1885; and appropriated $3,000 for all expenses.

"Since the passage of this law (May 17, 1886) the work has been progressing steadily and satisfactorily. Professor Orton has been successfully prosecuting his investigations on the subject of natural gas for the past year. In view of the great number of wells in construction throughout this section of the State, it is believed that the results of these investigations will have more than a passing interest and value."

The expenses of the survey up to July 13 amounted to $2,599.98.

"Looking at the great development of the mining and manufacturing interests since 1869, all of which is distinctly traceable to the work of the geological survey, it becomes evident that the work is not done yet; that there still remains a practically limitless field of work. Volume 6, it is hoped, will not terminate the series of valuable books which embody the researches of the faithful and efficient corps. At present, events seem to be shaping themselves for a small annual addition to this great treasure house. Such has been the successful policy of some of the States whose experience has been longer than ours; such will probably be our policy in the future.

"It is a matter of great regret that the work of the legislature upon the survey has to be reported as incomplete. The manuscript of volume 3, paleontology, in still in possession of the secretary of state, awaiting the decree for printing. It ought not to be allowed to remain there much longer. The reports on paleontology are indispensable to a trustworthy knowledge of geology. Ohio should follow the example of New York and give reports on paleontology to the world embodying the results of the explorations in this great field. Volume 4 also stands on the shelf companionless, deceiving the uninitiated with its illusory back. The early completion of this volume is to be earnestly desired, for the plants of Ohio certainly deserve some recognition."

The whole series, incomplete though it be, stands a living monument to the scientific acquirements, the fidelity and efficiency of the geological corps of Ohio, whose work will hold them in lasting remembrance. The State has reason for pride and self-gratulation upon the possession of such a valuable set of books.

Expenses.—The following tables, compiled under Professor Orton's direction, show the expenses of the various surveys from 1836 to 1886, inclusive:

Expenses of Ohio State Survey, 1836–1886.

Year	Purposes	Appropriations.	Total.	Disbursement.	Total.
1836	Expenses of committee (governor's contingent)	....		....	$400.00
1837	Expenses of geological survey	....	$12,000.00	....	2,089.57
1838	....do	....		....	9,648.89
1839	....do	....	4,000.00	....	4,261.63
1841	Arranging minerals collected	....	300.00	....	300.00
	Total expense of first survey	....	$16,300.00	....	$16,700.00
1869	Salary of chief	$3,000.00		....	
	Salaries of three assistants ($1,800)	5,400.00		....	
	Chemicals	500.00		....	
	Contingent expenses	5,000.00	$13,900.00	....	$3,066.61
1870	Salaries, chief and three assistants	5,950.00		$8,675.00	
	Chemicals	1,500.00		1,566.33	
	Contingent expenses and local assistants	9,800.00	17,250.00	9,574.47	19,815.80
1871	Salaries	8,400.00		8,175.00	
	Chemicals	500.00		500.00	
	Contingent expenses	12,000.00	20,900.00	13,168.19	21,843.19
1872	Contingent expenses	2,950.00		2,919.88	
	Salaries	2,450.00		4,775.00	
	Chemicals	100.00		100.00	
	Plates for volume 1	31,000.00		8,560.00	
	Continuing the survey	15,000.00	54 500.00	10,948.64	27,303.52
1873	Salaries	9,604.17		12,437.00	
	Contingent expenses	1,810.00		1,635.70	
	Zoological and botanical catalogues	1,000.00		500.00	
	Paleontological work	1,500.00		384.05	
	Additional maps	6,000.00		5,000.00	
	Chemicals	300.00		300.00	
	Plates for volume 1	....	20,214.17	25,319.47	46,276.22

Expenses of Ohio State Survey, 1836–1886—Continued.

Year	Purposes.	Appropriations.	Total.	Disbursement.	Total.
1874	Salaries	$1,000.00		$2,218.23	
	Publishing volume 2	60,000.00		12,616.71	
	Contingent expenses			201.72	
	Zoological and botanical catalogues			400.00	
	Plates for volume 1			420.53	
	Paleontological work		$61,000.00	1,115.95	$16,976.14
1875	Preparing and printing volume 2			37,276.75	
	Preparing and printing volume 3	15,000.00			
	Preparing for publication under J. S. Newberry	7,000.00	22,000.00		37,276.75
1876	Preparing and printing volume 2	2,784.49		12,885.29	
	Preparing and printing volume 3			4,987.24	
	Publication under J. S. Newberry		2,784.49	5,328.69	23,201.22
1877	Preparing and printing volume 3			4,028.21	
	Preparing report under J. S. Newberry	2,500 00		4,171.31	
	Preparing geological atlas	11,750.00	14,250.00		8,199.52
1878	Preparing reports	650.00		650.00	
	Completing volume 3 Paleontology	2,000.00		1,537.79	
	Publishing volume 4, Zoology and Botany	8,000.00			
	Preparing and printing volume 3		10,650.00	5,984.55	8,172.34
1879	Geological atlas			7,914.23	
	Preparing and printing volume 3	2,800.00		3,094.69	
	Publishing volume 4		2,800.00	1,454.42	12,463.34
1880	Geological atlas			3,777.77	
	Zoology and botany			3,670.62	7,448.39
1881	Zoology and botany (restored)	2,894.96	2,894.96	1,143.53	1,143.53
1881	Zoology and botany			1,495.80	
	Completion of volume 5	5,000.00	5,000.00	3,676.12	5,171.92
1883	Zoology and Botany			255.63	
	Completion of volume 5	15,300 00		7,732 30	
	Printing volume 4 in German	390.02	15,690.02	390.02	8,377.95
1884	Completion of volume 5			8,754.16	8,754.16
1885	Completion of volume 5			111.50	
	Preparation of volume 6	4,500.00	4,500.00	2,379.29	2,490.79
1886	Preparation of volume 6 (to July 13)	3,000.00	3,000.00	2,599.98	2,599.98
			$271,333.61		265,580.77
	Second survey:[1]				
	From appropriation for State printing				21,723.34
	From appropriation for stationery and envelopes				8,512.00
					295,816.11
	First survey; total cost of survey				16,700.00
					$312,516.11

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[1] The aggregates for the second survey to 1879 were given by Dr. J. S. Newberry as follows:

Field and office work	$98,914.17
Publication	206,788.78
	305,702.95
Add appropriations since made	28,190.02
	$333,892.97

Received under section 181, O. L. 77–241	$10,000.00
Transferred or lapsed appropriations:	
1875, zoological and botanical catalogue	100.00
1877, preparing and printing volume 2	5.74
1880, geological altas	58.00
1880, completing volume 3	167.52
1880, zoology and botany	2,874.96
1885, completing volume 5	135.92
	$3,342.14
Salaries and contingent expenses:	
1869	8,066.01
1870	19,815.80
1871	21,843.19
1872	18,743.52
1873	14,372.70
1874	2,422.95
	$85,264.17
1873, paleontology	384.05
1874, paleontology	1,115.95
	$86,764.17
Paid for survey from appropriation for State printing:	
1870, printing and engraving	391.13
1871, printing, engraving, maps, German printing	5,006.03
1872, printing, engraving, maps, translating, etc	10,475.26
1873, printing English and German	3,741.77
1874, printing German	1,048.75
1876, geological report in German	1,060.40
	$21,723.34
Paid from appropriations for stationery and envelopes	8,512.00

Number of copies printed (first series):	
1837, Hildreth's preliminary report	16,000
1837, Riddell's preliminary report	1,000
1838, first annual report	5,000
1838, queries from first annual	1,000
1839, second annual report	5,000

Eight thousand copies of Hildreth's Report were printed in connection with the governor's message, and 8,000 were printed separately.

There is no means of finding the cost of printing or paper of any of these documents. An estimate of the total cost of the first survey ($25,000) would place the cost of printing, etc., at $8,300.

Number and cost of copies printed (second series).

[From supervisor's report.]

Year.	Documents.	Number of copies.	Cost of printing.	Cost of paper.	Total cost.
1870	Report of 1869	2,500	$204.10	$246.74	$450.84
	Diagrams and maps		1,102.25		1,102 25
1871	Report of 1869 (2d edition)	10,000	1,950.56	1,406.45	3,357.01
	Report of 1869, German	2,000	619.20	294.74	913.94
	Report of 1869 (totals)	14,500	$3,876.11	$1,947.93	$5,824.04
1871	Report for 1870	12,500	1,252.89	5,845.94	7,098.83
	Lithograph maps for report	87,500	6,732.50		6,732.50
	Wood engraving for report		250.00		250.00
	Cases for the report	12,500	538.66		538.66
1872	Reprint of two forms	300	38.40	6.69	45.09
1872	Report of 1870, German	2,000	1,214.47	782.04	1,996.51
	Report of 1870 (totals)	14,500	$10,026.92	$6,634.67	$16,661.59
1872	Report of progress of 1871	300	8.06	4.99	13.05
1873	Volume 1, final report	18,000	4,390.54	7,683.97	12,074.51
	Volume 1, final report, German	2,000	845.55	853.77	1,699.32
	Volume 1. part 2, paleontology	18,000	3,312.77	8,512.00	11,824.77
	Translating report		362.27		362.27
	Report of 1871 (totals)	38,000	$8,911.13	$17,049.74	$25,960.87

The binding was done from the appropriation for State binding. The records do not show what amount was paid for any volume, so that the cost of binding these reports can only be estimated. All the expenses for the remaining volumes were provided for in the appropriation for the geological survey. According to Newberry, the cost was as follows:

Final report: volume 1, $69,381.94, or $3.47 a copy; volume 2, $62,778.75, or $3.14 a copy; volume 3, $27,782.48, or $1.39 a copy; geological atlas (5,000 copies), $11,692, or $2.34 a copy; volume 4, $8,410.02, or $0.42 a copy; volume 5, $10,237.79, or $1.02 a copy.

In 1889 appropriations for the renewal of the survey were made, in accordance with the following:

An act to provide for the extension of the geological survey of the State.

SECTION 1. *Be it enacted by the General Assembly of the State of Ohio,* That the governor is hereby authorized to appoint a State geologist, whose duty it shall be to continue and extend the investigations already made into the geological structure and resources of the State. Said State geologist shall be appointed for a term of three years, but he may be removed for cause at any time, and a successor appointed in his stead; and the governor is authorized to fill any vacancy which may occur from any cause, at any time. The compensation of said State geologist shall be at the rate of $200 per month, for the time actually employed; and said geologist shall have power to employ such assistants as he may need; but in no event shall the salary of the geologist, pay of assistants, and expense of the department exceed the amount of the expenditure authorized by the general assembly.

SEC. 2. It shall be the duty of said geologist to study, and determine as nearly as possible, the number and extent of the various formations of the State; to represent the same, from time to time, upon properly constructed maps and diagrams; to study the modes of occurrence and the distribution of the useful minerals and products of these formations; to determine the chemical composition and structure of the same; to investigate the soils and water supply of the State; and to give attention to the discoveries of coal, building stone, natural cement, petroleum, gas, and other natural substances of use and value to the State. He may also collect and describe the fossils of the various geological formations of the State; but no expenditure shall be incurred under this head that is not expressly ordered and provided for by the general assembly.

SEC. 3. The said geologist shall make, on or before the first day in February of each year, a report to the governor, covering the work of the preceding year, and the report shall be transmitted to the general assembly, to be printed in the same manner as other public documents, or as shall be otherwise ordered.

SEC. 4. The salaries of the State geologist and the assistants employed by him, together with the traveling and incidental expenses, shall be paid monthly, on presentation of properly itemized vouchers, signed by the governor, out of the State treasury, from the appropriation made for such purpose.

SEC. 5. There is hereby appropriated from the general revenue fund the sum of $1,000, annually, for the purpose above named.

SEC. 6. This act shall take effect and be in force from and after its passage.

Passed April 12, 1889.

Under this law, which may be considered as establishing the third organization for the purpose of making a geological survey of the State, Doctor Orton was again appointed State geologist, and continued to hold the office until the time of his death, which took place in October, 1899. From 1893 until this latter date, however, all work was practically suspended. Doctor Orton still held the position but no appropriations were made and the little work done was voluntary on his part.[1]

Under the organization above authorized, Prof. N. W. Lord, of the State university, served as chemist, and Prof. S. W. Robinson, also of the State university, as special assistant in the measurement of gas wells and pipe lines.

The first annual report under this organization bears the date of 1890, and is given up mainly to a consideration of the subjects of oil and gas.

After Doctor Orton's death the subject of the survey was taken up once more, and in 1900 a bill was passed appropriating $2,500 for the current year and $3,500 for the year 1901. Edward Orton, jr., became State geologist. The work of this survey, however, passes beyond the limit set for the present history.

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[1] See Bulletin No. 1, series 4, Geological Survey of Ohio, 1903.

PENNSYLVANIA.[1]

FIRST GEOLOGICAL SURVEY UNDER HENRY D. ROGERS, 1836–1842.

Organization.—In 1834 there was organized a geological society of Pennsylvania, the objects of which were declared to be:

> To ascertain as far as possible the nature and structure of the rock formations of the State; their connection or comparison with the other formations in the United States and of the rest of the world; the fossils they contain and their nature and positions and associations, and particularly the uses to which they can be applied in the arts, and their subserviency to the comforts and conveniences of men.

This society continued in existence but four years and left a single volume of transactions as tangible evidence of its career. It was, however, doubtless largely through the interest aroused by this society that there was established in 1836 a State geological survey. The following is the text of the original and supplementary acts:

An act to provide for a geological and mineralogical survey of the State.

SECTION 1. *Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in general assembly met, and it is hereby enacted by the authority of the same,* That the governor is hereby authorized and required, within 30 days after the passage of this act, to appoint a State geologist of talents, integrity, and suitable, scientific, and practical knowledge of his profession, who shall appoint as his assistants two geologists, also of integrity and competent skill, one of whom shall also be a scientific and practical mineralogist, and the said State geologist shall also appoint a competent, practical, analytical chemist to assist him in his duties.

SEC. 2. It shall be the duty of the State geologist and his assistants immediately to commence and to carry on with as much expedition and dispatch as may be consistent with minuteness and accuracy, and in accordance with a plan previously submitted to the secretary of the Commonwealth, a geological and mineralogical survey of the State, with a view to determine the order, succession, arrangement, relative position, and the dip or inclination, and also the comparative magnitude of the several strata or geological formations within the State, and to discover and examine all beds and deposits of ores, coals, clays, marls, and such other mineral substances as may be deemed useful or valuable, together with such other duties as may be necessary to make a full and complete geological and mineralogical survey of the State.

SEC. 3. It shall further be the duty of the said State geologist, on or before the 1st day of January in each and every year, during the time necessarily occupied by said survey, to make an annual report of the progress of said survey, accompanied with such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same to the secretary of the Commonwealth, who shall immediately lay such report before the legislature.

SEC. 4. The said State geologist is further required to cause to be represented on the map of this Commonwealth, by colors and other appropriate means, the various areas occupied by the different geological formations in the State,

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[1] Compiled in part from manuscript notes by J. P. Lesley in 1886.

HENRY DARWIN ROGERS

STATE GEOLOGIST OF NEW JERSEY, 1835 40, AND OF PENNSYLVANIA, 1846 52.

and to mark thereon the localities of the respective beds or deposits of the various mineral substances discovered, and on the completion of the survey to compile a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

SEC. 5. The said State geologist shall also send to the secretary of the Commonwealth such specimens of the rocks, ores, coals, soils, fossils, and mineral products discovered, as he may deem necessary and proper, in order to form a complete cabinet collection of specimens of the geology and mineralogy of the State, and the said secretary of the Commonwealth shall cause them to be deposited in proper order, in some convenient room in the State capitol, there to be preserved for public inspection. The said geologist is further required to furnish similar specimens of geology and mineralogy of each county in the State to the commissioners of said county, who shall cause the same to be properly deposited and arranged for public inspection in a room in the county courthouse, or some other convenient place in the county.

SEC. 6. It shall be the duty of the chemist appointed as aforesaid to make full and complete examinations, assays and analyses of all such rocks, ores, soils, mineral substances, and mineral waters as may be submitted to him by the State geologist, and to furnish him with a detailed and complete account of the results so obtained.

SEC. 7. For the purpose of carrying on and completing the said geological and mineralogiacl survey, the sum of $6,400 is hereby annually appropriated for five years, to be expended as follows: For the annual salary of the State geologist, $2,000; for that of each of the assistant geologists, $1,200; and for the annual compensation of the chemist, in full for all services performed and expenses incurred by him, $1,000; the remaining $1,000, if necessary, to be appropriated to the incidental expenses of the geologists, incurred in the prosecution of the survey, and the duties enjoined on them by this act: *Provided*, That the said salaries shall not commence until the said geologists and chemist shall have entered upon the execution of their duties, and that on the completion of said survey and the duties connected with it they shall wholly cease and determine.

Approved March 29, 1836.

A supplement to the act entitled "An act to provide for a geological and mineralogical survey of the State," passed March 29, 1836.

SECTON 1. *Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania, in General Assembly met, and is hereby enacted by the authority of the same*, That the State geologist be, and he is hereby, authorized to appoint two additional assistant geologists, who shall possess the same qualifications, and receive the same salary as those appointed under the act to which this is a supplement, and that the annual report of the said State geologist shall be made to the legislature on or before the 1st day of February in each year.

SEC. 2. For the payment of the said additional assistant geologists, and such expenses as may be incurred in the formation of the State and county cabinet collections of mineral specimens, with other incidental expenses, incurred in the prosecution of the survey, the sum of $3,000 is hereby added to the future annual appropriation mentioned in the seventh section of the act to which this is a supplement.

SEC. 3. So much of the act to which this is a supplement, as is hereby altered or supplied, shall be, and the same is hereby, repealed.

SEC. 4. The governor of this Commonwealth is hereby authorized to draw his warrant upon the State treasurer, on the 1st day of April next, in favor of the treasurer of the "Franklin Institute of the State of Pennsylvania, for the promotion of the mechanic arts," for the sum of $2,000; and for the further sum of $1,000, on the 1st day of April for each of the two years next ensuing, for the purpose of promoting the improvement of meteorological science, and the furnishing of each county of this Commonwealth with the necessary instruments for the observation of such atmospheric changes and phenomena as may be useful for the promotion of knowledge in the science of meteorology.

Approved March 21, 1837.

An act of 1838 provided:

SEC. 12. That in order to complete the geological and mineralogical survey of the State more rapidly, and to secure to the people the benefits thereof, as nearly as practicable at the same time, the sum of $6,000 is hereby added to the future annual appropriations mentioned in the seventh section of the act passed March 26, 1836, entitled "An act to provide for a geological and mineralogical survey of the State," to be expended by the State geologist, with the approbation of the governor, in the employment of such additional subassistant geologists and a draftsman, as may be deemed necessary for the rapid completion of the survey: *Provided*, That the salaries of the said assistant geologists shall not exceed $800 per annum each, and the salary of the draftsman shall be $1,200 per annum; and it shall be the duty of the State geologist, in addition to the duties now imposed upon him by law, to make such inquiries and examinations into the present methods of mining coal and manufacturing iron as the governor shall deem expedient and proper, to increase the products of the mineral resources of the State, and when the said inquiries and examinations are completed, the said State geologist shall compile a complete and detailed report thereof, and present the same to the legislature as soon as practicable.

Approved April 13, 1838.

Again, in 1840 it was provided:

That the sum of $10,200 shall be, and the same is hereby, appropriated for the completion of the geological and mineralogical survey, to be applied as follows: Two thousand dollars for the payment of one year's salary to the State geologist; $6,000 to the payment of one year's salary of six assistants, including the chemist, at the rate of $1,000 each; and the remaining sum of $2,200 to be paid to and applied by the said geologist to the payment of the incidental expenses of said survey, including the preparation of three complete collections or cabinets of geological and mineralogical specimens, for the use of the State, and for the compiling and preparing for publication the final report in relation to said survey, together with the maps and drawings to accompany the same, which said sum shall be deemed and taken as full compensation therefor.

Section 17 of the act of 1844 provided:

For the completion of geological survey, $2,200 to be applied to the payment of the incidental expenses of the geological survey, including the preparation of the general cabinet collections of geological and mineralogical specimens and the maps and drawings assigned to accompany and elucidate the final report of the State geologist; and the governor is hereby further authorized to take such other measures as in his opinion the public interest may require in relation to the reception and protection of said final reports, maps, drawings, and cabinet collections; which sum shall be deemed and taken as full and final compensation for completing the same as per act of May, 1841. For continuing the meteorological observations in the several counties of this Commonwealth, according to the provisions of the fourth section of the act of March 21, 1837, $300: *Provided*, That the State geologist shall give bond with sufficient sureties, to be approved by the governor, conditioned for the completion of the work according to existing laws.

Administration.—Under the act approved March 29, 1836, Prof. Henry D. Rogers was appointed State geologist, retaining the office until the final abolition of the survey and the publication of the report in 1858. He was assisted from time to time as follows: In 1836, by John F. Frazer and James C. Booth; in 1837, Messrs. S. S. Haldeman, A. McKinley, C. B. Trego, and J. D. Whelpley, with Dr. R. E. Rogers as chemist. In 1838, Messrs. H. D. Holl, J. T. Hodge, R. M. Jackson, J. C. McKinney, P. W. Schaeffer, T. Ward, and M. H. Boye were added to the force. In 1839 J. Peter Lesley and Doctor Henderson were added in place of Messrs. Whelpley and McKinney, who resigned. In 1840 the personnel was essentially the same. In 1841 it was reduced to Messrs. McKinley, Holl, Jackson, Lesley, Boye, and Doctor Rogers. In 1851 the geological assistants were Prof. E. Desor and W. B. Rogers, jr., Peter Lesley and A. A. Dalson serving as topographers.

The salaries of these assistants, as noted, were fixed by law. That of the State geologist, by the act of 1836, was fixed at $2,000 a year, and those of the assistant geologists and chemist at $1,200 and $1,000, respectively. By the act of 1838 the salaries of a draftsman and subassistant geologists were fixed at $1,200 and $800, respectively. Under the act of 1840 the salaries of the six assistants, including the chemist, were made $1,000 each.

During the first year of the survey (according to J. P. Lesley) the general order and character of the 13 Paleozoic formations were obtained and the foundation laid for Paleozoic geology in America, requiring no essential change from that time to the present, at least along the Appalachian belt. After the first year the State was divided into general geological districts, to the particular study of which the several assistant geologists were from year to year assigned. Their reports were embodied in the first five of the annual reports of the State geologist to the legislature.

The work of the first six years was of the nature of a geological reconnoissance of a very thorough character, covering the entire area of the State, amply sufficient at that time for the information of its citizens, largely contributing to the creation of the science of geology, establishing new principles of structure, and mediating sufficiently between the paleontological differentiations of the New York and Canadian outcrops to the north and the geological surveys of Booth in Delaware, Ducatel in Maryland, William B. Rogers in Virginia, Emmons in North Carolina, Tuomey in South Carolina, Troost and Safford in Tennessee, D. D. Owen in Kentucky, and other geologists in the Western States and Territories.

As a reconnoissance it was a brilliant success. The accuracy of its determinations on a large scale have never been impugned. None of its important data have been falsified by subsequent examinations. The mistakes it made were without exception errors of detail, mainly due to the then wild and unsettled condition of large districts of the State and the slight development of its mineral beds, but largely also to the slender fund placed at the disposal of the State geologist annually, which prevented him from undertaking the necessary instrumental work for the accurate measurement of sections and location of lines of outcrop on the map. The geodetic determination of geographical data was impossible.

This lack of precision, while it did not affect practically the value of the geological knowledge obtained and published provisionally in the annual reports, was destined to be severely felt when the final report came to be written and a geological State map prepared. It gave, as it was sure to give, to the whole final report a general tone of uncertainty respecting the actual thickness of formations and in many cases to the identification of beds and groups of beds at places distant from each other, especially in the coal regions. Had money been at command for instrumental work, many of the great problems in the anthracite region, which have since been settled, would have been settled then, and large sums of money would have been saved to the anthracite industry. The same was true respecting the iron industry. But 50 years ago [i. e. about 1836] the practical importance of accurate scientific geological surveys was not appreciated, and the people of Pennsylvania permitted the geological survey of the State to pursue its course under the most onerous disabilities and to stop at precisely the point where its utility was becoming real. At this point the work was resumed in 1874, after an interval of 33 years, since which the State survey has simply been a practical consummation of the earlier preparatory work.

The lack of precise instrumental work was most severely felt in the preparation of the geological map, for which there was no sound basis whatever and in which every geographical error on Melish's old State map and on the few county maps which existed was necessarily either reproduced or modified into some equally objectionable form. So great was the confusion of errors on the maps at the command of the geological survey that an aggregate error in longitude of more than 3 miles was concentrated from east and west along the line of the Susquehanna River, and was then redistributed eastward and westward toward the New Jersey and Ohio State lines. Had it not been for the small scale on which the State map was drawn (5 miles to the inch) the distortion of the geological outcrops, colored to represent the formations, would have been flagrant.

Museums.—Section 5 of the act of 1836 directed the State geologist to make collections of rocks, ores, coals, soils, fossils, and mineral products in order to form a complete cabinet of specimens, which the secretary of the Commonwealth should cause to be deposited in proper order in some convenient room in the State capitol. He was further directed to furnish similar specimens of the geology and mineralogy of each county in the State to the commissioners of said county, who should cause the same to be properly deposited in a room of the county courthouse or some convenient place for public inspection. The act of 1840 authorized the preparation of three complete collections "for the use of the State." An act of 1848 provided:

> That on application to that effect the secretary of the Commonwealth be directed to deposit with the Western Pennsylvania University of the city of Pittsburgh, the fourth collection of geological and mineralogical specimens now in Philadelphia, which said fourth collection as made by Professor Rogers from the principal collections originally deposited in Harrisburg and Philadelphia shall in no manner be disturbed or impaired by such deposit at Pittsburgh.
>
> *Resolved*, That the collection of geological and mineralogical specimens collected by Professor Rogers to be deposited in Philadephpia, and which is now stored in that city be, and the same is hereby, presented to the corporation of the city of Philadelphia, on condition that the said corporation shall, within one year, deposit the same in some public building or public institution in Philadelphia, where it shall be duly arranged in scientific order, and marked as the collection made by the State, and be kept open at all proper times for public inspection, free of charge.

Expenses.—The total appropriations for the survey, including those of the supplementary acts for its completion, amounted to $66,000, exclusive of the cost of preparation of manuscript and the publication of the final report.

Publications.—During the period of its existence the survey issued six annual reports, the first bearing date of 1836 and the last 1842. These were small octavo volumes, destitute of illustration, with the exception of a few outline sections, and of 100 to 250 pages each.

The survey, as noted, came to an untimely end in 1842. Rogers, however, being unwilling to relinquish the work in its unfinished condition, continued at his own expense until he was able, in 1847, to make his final report to the office of the secretary of the Commonwealth. Here the manuscript was allowed to lie until, in the spring of 1851, appropriations, which were continued until 1855, were made for revising it and bringing it up to date. The total cost of publication of this final report, two large quarto volumes of 1631 pages, 23 full-page plates, 18 folded sheets of sections, and 778 figures in text, was $16,000, and the edition limited to 1,000 copies. The following is the text of the law under which this final report was ultimately published:

An act supplementary to an act entitled "An act to incorporate the Byberry & Poquesen Turnpike Road Co., and relative to the publication of the final report on the geological survey of the State," approved April 14, 1851.

SECTION 1. *Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania in General Assembly met, and it is hereby enacted by the authority of the same,* That, in addition to the persons heretofore provided for in said act, the members and the principal and assistant clerks of each house of the general assembly, for the year 1855, shall be entitled to receive one copy of the State geological survey, and one copy shall also be sent to each State government, to the Congressional Library, and to each public library of this Commonwealth: *Provided,* That no individual member, clerk, or library shall be entitled to receive more than one copy of said work.

SEC. 2. That the secretary of the Commonwealth be, and he is hereby, directed to contract with Prof. Henry D. Rogers for the publication of the final geological report of the survey made by him on behalf of the State, with the accompanying maps, plates, cuts, and engravings, and the furnishing to the State of 1,000 copies thereof, according to the proposals, specifications, and contract adopted and entered into between the Commonwealth and Hogan & Thompson in the year 1851: *Provided,* That the said contract shall stipulate for the complete publication and delivery of said work, within three years from the 1st day of April, 1855; and the said Henry D. Rogers shall enter into a bond, with sufficient security, for the faithful performance thereof.

SEC. 3. That the secretary of the Commonwealth is further authorized to stipulate in said contract for the publication of the large State map, accompanying said report, upon twice its present scale: *Provided,* That the additional cost of said enlargement shall not exceed the sum of $2,000.

SEC. 4. That the sum of $19,000 is hereby appropriated for the purposes aforesaid, to be paid on the warrants of the governor, as follows, to wit: Three thousand dollars on the 1st day of October next; $3,000 on the 1st day of April, 1856; $7,000 on the 1st day of April, 1857; and the last installment as soon as 1,000 copies of said work are delivered, according to the said contract; but before the payment of either of these installments the secretary of the Commonwealth shall be satisfied of the due progress of said work: and all former appropriations to said objects be, and the same are hereby, repealed.

Approved May 3, 1855.

SECOND GEOLOGICAL SURVEY UNDER J. P. LESLEY, 1874–1888.[1]

In 1851, 10 years after the close of field work in 1841, the legislature voted an appropriation for publishing a final report of the first survey. The State geologist then revisited portions of the State, especially the anthracite region, with the help of Messrs. P. W. and

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[1] Compiled almost wholly from a manuscript by J. P. Lesley, written in 1886.

J. PETER LESLEY

STATE GEOLOGIST OF PENNSYLVANIA, 1874 1903.

John Sheafer, E. Desor, Leo Lesquereux, J. P. Lesley, A. A. Dalson, W. B. Rogers, jr., and Mr. Poole, and published the Geology of Pennsylvania in 1858, as already noted.

In the interval of 13 years between 1841, when the first survey stopped, and 1854, when all official field work practically ceased, a great development of the coal and iron industries of the State took place. Hundreds of mines had been opened; many new mineral districts had been prospected and more or less occupied; railroad cuttings had exposed a multitude of measurable outcrops; the statements of the first survey had been criticized and verified, and a large body of fresh data added.

In the next interval of 20 years, between 1854 and 1874, a far greater change took place. The discovery of rock oil in 1859 converted in a few years the silent forests of northwestern Pennsylvania into an open region, crowded with villages, towns, and cities, animated with a geological fury for investigation, and penetrated to a depth of 2,000 feet by many thousand bore holes; so that no part of the earth's crust ever was or is ever likely to be again so completely and minutely explored; nor was ever so vast an accumulation of stratigraphical data thrown together in a heap at the feet of the science.

Then came the war of secession and an unprecedented demand for iron, and for coal to smelt iron. One-half the annual product of both iron and coal in the United States has always come from Pennsylvania. Abandoned mines were reworked, new ones opened, furnaces enlarged, collieries deepened and extended. Every outcrop of iron ore, good and bad alike, was traced and tried; every outcrop of black slate exposed to eager inquisition. A multitude of private surveys took place in all parts of the State, and a world of fresh data, of a specially precise kind, was accumulated, which appealed to a largely increased geological intelligence in the public mind.

The invention of Bessemer iron when introduced into Pennsylvania in 1867 not only intensified the critical search for ore, but multiplied the number and improved the quality of metallurgical experts, and thus exercised an important influence upon the sentiment of the Commonwealth toward geology as an applied science. There was a continually louder call for geological facts. But there was no State bureau of geology nor any officer of the Commonwealth from whom such could be obtained. All surveys were private; all reports confidential. Business refused to give away its valuable secrets. The publications of the first State survey were out of print and out of date; would not answer questions if they could, and could not if they would; for the lifetime of a generation had elapsed and a new survey of the State was needed, under better auspices and with vastly greater advantages; a survey not so much for the discovery of the unknown as for making known to the public discoveries which in a multitude of private hands awaited publication; a survey not so much for the mere publication of this vast concealed store of facts as for the critical examination and discussion of them, putting them into true relationship to each other, getting from such discussion intelligent comprehension of what was known and what still remained unknown, and clear indications of how the investigation of the geology of the State should be pursued.

Such, then, was the animus which inspired a limited number of the most intelligent citizens of the State to obtain, in 1873, an act of the legislature for the geological survey of Pennsylvania.

The immediate motive for the survey was probably the clamor of the oil men in 1873 for a survey of the oil regions, for in that year the annual production of petroleum suddenly advanced from 6,000,000 to 10,000,000 barrels, while the price of a barrel sank from $4 to $2, throwing western Pennsylvania into a state of the highest excitement, reflected by the stock exchanges in every city, and riveting the attention of merchants at European ports. Every one was asking: How long will the flow of oil last? What is its original source? Where are the limits of its reservoirs? Who can give us a rule to locate a well? How many oil sands are there? Can geology teach us anything? Why does the State legislature not provide for a scientific examination of the phenomenon?

The three other great mineral industries of the State—iron, anthracite, and coking coal—thought that they knew their geologies sufficiently well, and one of them at least, the anthracite, had special business reasons for not pressing its claims to a resurvey; for the railroad companies were acquiring and consolidating the collieries, and desired no interference; the bituminous coal measures were well understood in the local districts which produced most; and the ironworks had their own geological advisers.

But when the demand for a State survey was made by the oil interest it was supported by intelligent men from all parts of the State, each district hoping for discoveries valuable to itself, and the poorer counties believing that their mineral poverty was merely a mistake or oversight chargeable to the inadequacy of the old survey.

The legislative act instituting the survey was couched in the following terms:

Section 1. *Be it enacted, etc.,* That the governor, with the advice and consent of the senate shall, as soon as practicable after the passage of this act, appoint 10 suitable commissioners from different sections of the State, who, with the governor as chairman *ex officio*, shall constitute a board to prosecute the work contemplated in this act; the persons so appointed shall hold office during the continuance of the work, and any vacancies in their number caused by death or resignation shall be filled by the governor with the consent of the senate.

SEC. 2. The commissioners before entering on their duties, shall respectively take and subscribe the oath required of other State officers, which shall be filed in the office of the secretary of the Commonwealth, who is hereby authorized and directed to administer said oath.

SEC. 3. The said board is hereby authorized to rent rooms in Harrisburg at a moderate and usual rent, to use for the purposes of the survey created by this act, and shall therein also hold its regular meetings: such meetings shall be held at least once in every three months and as much oftener as required by the exigencies of its affairs, and the due furtherance of the survey; the time for the regular meetings shall be fixed at the time of its organization.

SEC. 4. The commissioners shall receive no compensation for services but their actual traveling and other necessary expenses, which shall be paid by the State treasurer on the certificate of the auditor general; and no commissioner or officer under this act shall derive pecuniary profit from the appropriation made by this act, other than is specified.

SEC. 5. The board shall be convened by the governor as soon as practicable, and it shall have power to make such regulations for the management of its business as it may deem expedient, and may, if necessary, employ a clerk.

SEC. 6. The board created by this act shall, on its organization, take charge of and conduct as it may deem to the best interests of the State, the business of organizing a thorough and extended geological survey of the State. The purpose of the said survey shall be to make such investigations as may be required to thoroughly elucidate the geology of the State and put the result of this and previous work of individuals or surveys into a convenient form for reference; and further, to make such full chemical examination of ores, coals, oils, clays, soils, fertilizing, and other useful minerals and waters as shall be required to afford the agricultural, mining, metallurgical, and other interests of the State a clear insight into the character of its resources. The said board shall also cause to be collected such specimens as may be necessary to form a complete cabinet collection of specimens of the geology and mineral resources of the State.

SEC. 7. To carry out the purposes of this act the board is hereby authorized and required to appoint a State geologist of ability and experience, who shall control the execution of the details of the survey; and the said geologist shall appoint such competent assistants as may be required to carry out the purposes of the survey, none of whom shall be members of the board. All salaries shall be fixed by the board, which is hereby required to make yearly agreements with the geologist and his assistants as to their salaries. It shall also fix the rates at which the geologist may employ such temporary assistants as he may require. The work of the survey shall be done on such plan as shall be approved by the board. On the adoption of the plan, the geologist shall immediately and thereafter as often as may be required, make out estimates for all necessary implements and materials for the work, and for all necessary expenses, and these estimates shall be submitted to and be subject to the approval of the board. The said State geologist, with his assistants, shall be under the control of the board, but after the approval of the plan submitted by the geologists his assistants shall be responsible to him for the proper execution of their work. The State geologist shall be present at the meetings of the board and take part in its discussions.

SEC. 8. The said board shall collect copies of the surveys of this and other States and counties, and shall digest the information therein contained to the end that the survey created by this act may be made as thorough, practical, and convenient as is possible. All works so collected shall be the property of the State. It shall further be the duty of the members of the board, in addition to those already specified, to furnish, from time to time, to the State geologist, any and all information which will contribute to the development of the facts relating to the mining, agricultural, and other pursuits of the State.

SEC. 9. It shall be lawful for all persons employed by the geological survey created by this act to enter, without molestation, into and upon all lands and localities in this State which it may be necessary to examine for the purposes of this survey. The board shall avail itself, as fully as possible, of the information, maps and surveys possessed by citizens and corporations in this State relating to the geology and topography of the State. All the facts, of whatever nature, obtained by the survey shall be considered public property, and any concealment or speculative use of the same is strictly prohibited. All publications of the board shall be copyrighted by it in the name of the State.

SEC. 10. And it shall be the duty of the State geoolgist annually, before the 15th day of February in each year, to prepare a detailed report of the operations of the year, and the facts obtained by the survey; he shall submit the same to the board, which is hereby authorized to print and publish the said reports in a suitable and convenient form, adapted to modern requirements. Copies of the reports, with all maps and supplements, shall be donated to all public libraries, universities, and colleges in the State, and shall be furnished at cost of publication to all other applicants for them.

SEC. 11. To carry out the purposes of this act, the sum of $35,000 is hereby annually appropriated for three years. All expenditures made in carrying out this work shall be, after the approval of the board, certified by the same, upon proper vouchers, to the auditor general, who shall draw his warrant upon the State treasurer for the amount: *Provided*, That no salaries or other expenditures under this act shall commence until the officers herein named have entered upon the execution of their respective duties.

Approved May 14, 1874.

Acts granting appropriations and supplementing or modifying the original act, from time to time, were as follows:

Act of May 13, 1876.

Be it enacted, That for the purpose of continuing the geological survey of the State the sum of $15,000 be appropriated for the year 1876, and the sum of $50,000 for the year 1877; and said sum shall be expended in conformity with the act approved May 14, 1874, entitled "An act to provide for a geological survey of the State."

Act of April 18, 1877.

Be it enacted, That the sum of $10,000 is hereby appropriated, to be expended according to the provisions of an act, entitled "An act to provide for a geological survey of the State," approved May 14, 1874, $50,000 for the work of the year 1878, and $50,000 for the work of the year 1879.

Act of June 11, 1879.

Be it enacted, That the sum of $50,000 is hereby appropriated, to be expended according to the provisions of an act, entitled "An act to provide for a geological survey of the State," approved May 14, 1874, for the work of the year 1880.

Act of May 26, 1881.

Be it enacted, That the sum of $125,000 be, and the same is hereby, appropriated, to be expended according to the provisions of an act, entitled "An act to provide for a geological survey of the State," approved May 14, 1874: *Provided*, That not more than $50,000 shall be expended in any one year: *And provided further*, That the said survey shall be completed, so far as the field work is concerned, by the end of the calendar year 1883.

Act of June 28, 1883.

Be it enacted, That the sum of $50,000 is hereby specially appropriated for the continuance of the geological survey of the anthracite coal region of the State, to be expended according to the provisions of an act entitled "An act to provide for a geological survey of the State," approved May 14, 1874: *Provided*, That any expenditure for said anthracite survey which shall have been paid out of the appropriation for the general survey of the State, after the first day of January, 1883, and prior to the passage of this act, may be reimbursed to said general appropriation out of the special appropriation hereby made.

Act of July 3, 1885.

Be it enacted, That the sum of $50,000 be, and the same is hereby, appropriated to be expended, according to the provisions of an act, entitled "An act to provide for a geological survey of State," approved May 14, 1874: *Provided*, That not more than $19,000 be expended annually to continue the anthracite survey, and not more than $2,000 be expended annually to extend the oil and gas region survey; and not more than $4,000 shall be expended annually to extend the survey in the bituminous regions of the Monongahela Valley and Pittsburgh coal regions, and continue unfinished surveys in the iron-ore regions.

Acts respecting the publications of the survey, etc.:

Joint resolution of March 18, 1875.

Resolved, That 5,000 copies be printed of the report on the mineralogy of Pennsylvania, by F. A. Genth, and the special report on petroleum, by Henry E. Wrigley, with accompanying maps and charts, reported by the board of commissioners of the geological survey of Pennsylvania, 1,000 copies for the use of the senate and 4,000 copies for the use of the house of representatives.

Act of April 18, 1877.

SECTION 1. *Be it enacted*, That the board of commissioners of the second geological survey of the State be, and they are hereby, authorized to donate a copy of each report and map published by them to every member of the geological corps, and to each author of a report 20 copies of such report, and to distribute gratuitously 50 copies of each report; and to sell copies of the reports to booksellers at a reasonable discount on their value.

SEC. 2. That the commissioners of the second geological survey shall furnish to the senate and house of representatives, for distribution among the people of the State, 10,000 copies of the reports now on hand in their department, as they may select; 3,000 for the use of the senate and 7,000 for the house; and they shall also furnish in the same ratio 1,500 copies of each of the forthcoming reports designated, respectively, C and HH: *Provided*, That nothing in this act shall be construed to authorize the reprinting of any of the reports aforesaid.

SEC. 3. That 1,000 copies of each of the reports in the hands of said commissioners be placed at the disposal of the executive department of the State for distribution to other States and counties and public institutions.

Act of March 15, 1878.

Be it enacted, That the commissioners of the geological survey shall furnish the senate and house of representatives, for distribution to the people, 1,000 bound copies of each of the volumes marked, respectively, HHH and II, and also a like number of bound copies of each of the forthcoming reports of the survey, 350 of each for the use of the senate and 650 for the use of the house. They shall also furnish to the executive department 100 bound copies of each of the reports as above for distribution to other States and public institutions.

Joint resolution of May 3, 1878.

Resolved, That there be printed for the present year for the use of the senate and house of representatives 3,500 copies of each volume of the geological survey reports heretofore issued, and a like number of each volume of the reports of said survey which are now in process of publication; 1,000 copies of each volume for the use of the senate and 2,500 for the use of the house of representatives.

Joint resolution of March 28, 1879.

Whereas with one or two unimportant exceptions, all the known accessible anthracite coal in the world is found within the limits of the State of Pennsylvania; and

Whereas by various enactments of former legislatures of this Commonwealth, the care and management of these precious deposits of fuel, which are very limited in extent, have been committed to bodies corporate with almost unlimited powers and with consequent responsibilities; and

Whereas the anthracite coal fields, the seat of the most important mineral interest in the State, is rapidly becoming exhausted under the present wasteful and unprofitable system of mining and selling the same, which is returning no just recompense to the land owner, the operator, the miner: Therefore

Be it resolved, That the board of commissioners of the geological survey of the State be requested to cause a survey and examination of the anthracite coal region to be made, paying special attention to the question of the rapid exhaustion of this most valuable deposit, more economy in the methods of mining, and the avoidance of the great waste and overproduction now threatening ruin to all interested in the trade, and to make a special report with reference to these subjects, and suggesting if possible a remedy for the evils above recited.

Act of June 12, 1879.

Whereas the commissioners of the second geological survey of Pennsylvania have had printed, and now hold in reserve, 2,500 copies of the larger maps and other illustrations accompanying the several reports of said survey, and as said reports are required by the citizens of this Commonwealth: Therefore

Be it enacted, That there be printed for the present year 2,500 copies of each volume of the geological survey reports heretofore and hereafter to be issued; 600 copies of each volume for the use of the senate, and 1,900 of each volume for the use of the house of reperesentatives; and the commissioners of the geological survey are hereby directed to deliver to the superintendent of public printing and binding the maps and illustrations already printed and in their possession, in order that they may be bound in the volumes directed to be furnished by this act: *Provided*, That the maps and illustrations already printed, and the stereotype plates used in printing the edition now called for shall not be charged a second time by the State printer.

Act of April 4, 1883.

Whereas the Academy of Natural Sciences of Philadelphia, a society founded in 1812, and lawfully incorporated in 1817, for the encouragement and cultivation of the sciences, and devoted entirely to the advancement of useful learning, has signified its willingness to assume the custody of the collections of specimens made by the second geological survey of Pennsylvania, and to freely exhibit the same, without rental or other charge to the State: Therefore

Be it enacted, That the commissioners in charge of the second geological survey of Pennsylvania be, and are hereby, authorized and directed to deliver free of expense to the Academy of Natural Sciences of Philadelphia the specimens collected during the survey, which specimens are to remain in the custody of the Academy until otherwise provided by law, as the property of the State, to be exhibited without fee to those persons who may desire to view or study the same at such times and under such rules as may be prescribed by said academy from time to time.

Act of July 3, 1885.

Whereas by section 10 of an act approved May 14, 1874, entitled "An act to provide for a geological survey of the State," it is provided as follows: "Copies of the reports with all maps and supplements shall be donated to all public libraries, universities, and colleges in the State, and shall be furnished at cost of publication to all other applicants for them"; and

Whereas the sale of these reports has almost ceased by reason of the gratuitous distribution thereof under subsequent acts of assembly, authorizing the printing of copies of the said reports for the use of members of the legislature: and

Whereas there remain in the custody of the board of commissioners of the geological survey large numbers of these reports, which, for the reason above mentioned, can not be sold, and which, under existing laws, can not be otherwise distributed: Therefore,

SECTION 1. *Be it enacted*, That the board of commissioners of the geological survey are hereby authorized to retain 100 copies of each report heretofore published, and the said board are directed to distribute the remaining copies of said reports as follows: Fifty copies of each report to the State librarian for distribution and exchange with other States and Territories, and of the balance an equal number of volumes to each member of the present senate and house of representatives, making the sets complete as far as practicable.

SEC. 2. That of each report hereafter published, 3,500 copies shall be printed, which shall be distributed by the board of commissioners as follows: Five hundred copies to the senate, 2,000 copies to the house of representatives, 150 copies to the State geologist, out of which he shall donate copies to authors and to members of survey corps as heretofore granted, 600 copies to the board of commissioners for distribution to public libraries, universities, and colleges in the State, to parties rendering material assistance to the survey, and for exchange with foreign societies and geologists; and 50 copies thereof to the members of the board; 100 copies to the secretary of internal affairs for distribution by him; 100 copies to the governor for distribution by him; and

50 copies to the State librarian for distribution and exchange with other States and Territories.

SEC. 3. That so much of the act of May 14, 1874, recited in the preamble, as requires the reports to be sold, and all other acts and parts of acts inconsistent herewith, be, and the same are hereby, repealed.

Administration.—In accordance with the act of assembly Gov. John F. Hartranft appointed 10 citizens of the State to act as a board of commissioners to execute the survey: Ario Pardee, of Hazleton: William A. Ingham, of Philadelphia; Henry S. Eckert, of Reading; Henry McCormick, of Harrisburg; James Macfarlane, of Towanda; John B. Pearse, of Philadelphia; Robert V. Wilson, M. D., of Clearfield; Hon. D. J. Morrell, of Johnstown; Henry W. Oliver, of Pittsburgh; and Samuel Q. Brown, of Pleasantville, as representing all parts and important interests of the State. Governor Hartranft was himself chairman and Mr. Pearse secretary of the board. In 1878 Doctor Wilson died, and Charles A. Miner, of Wilkes-Barre, was appointed in his place. In 1879 Mr. Pearse removed to Boston and Joseph Miner, of Luzerne County, was appointed. In 1879 Mr. Oliver, then candidate for United States Senator, resigned, and Lewis W. Hall, of Harrisburg, was appointed. In 1885 Senator Morrell died, and Charles H. Noyes, of Warren, was appointed. In 1885 Mr. Macfarlane died, and Jacob Turner, of Greensburg, was appointed.

In June, 1874, the board met, organized, and appointed J. P. Lesley, professor of geology in the University of Pennsylvania, State geologist. The State geologist, in obedience to the terms of the law. submitted to the board a plan of survey, which was accepted and put at once into execution July 1, 1874. He appointed five assistant geologists, to commence work in as many districts of the State, each with one or more aids for instrumental work; one topographer at headquarters, who acted also as clerk and accountant; one chemist, with a laboratory at Harrisburg, and a mineralogist.

At the end of the year, when the collections had come in, a museum was established and a paleontological curator appointed.

In 1875 two more assistant geologists were appointed to commence work in two other districts, making seven in all, and also a paleobotanist. This completed the plan of the survey, which remained practically unchanged for five years, being modified only by the promotion of aids to take the place of assistants who resigned, by the detail of the curator of the museum to a special geological district. by the appointment of new aids as they were wanted, and by the appointment of young volunteers, who served for their expenses and the knowledge they acquired.

At each quarterly meeting of the board the State geologist reported the progress of the survey, his plans for the ensuing three months, any new appointments he might have made, any advance of salary to any aid or assistant, and his estimate of expenses for the quarter in advance; all of which was discussed and acted upon by the board at their pleasure. The regular quarterly meetings were held at Harrisburg; special meetings, on occasion, either there or in Philadelphia. No business could be transacted unless five commissioners were present. Usually eight or nine and sometimes the whole board assembled. On emergencies copies of needful acts were sent by mail to each commissioner's home in advance of a meeting, and to absentees after the meeting, to secure unanimity of action; the policy of the board being to postpone consideration of all plans not unanimously approved, which accounts for the success of the survey.

Both assistant geologists and aids were expected to devote themselves exclusively to the survey, and to have no private professional business within the limits of the State. Eleven months of their time each year were due to the survey for field and office work; the remaining month was their own, as a vacation, salary paid as usual, but no expenses. This they might and sometimes did employ, outside the State, in some professionally profitable way. No charge was ever made to any citizen of the State for any geological, mineralogical, or chemical information which the survey could communicate; nor was any verbal information withheld from any citizen until publication; but all written information capable of being used for trade purposes was forbidden. No fee was ever accepted from any capitalist or company for taking up one line of survey in preference to another or out of its proper order.

The survey had no connection, officially or unofficially, directly or indirectly, with other institutions in the State, except in the one particular that the State geologist was also the official geologist of the State board of agriculture.

In two cases the assistant geologist was a college professor, and only served the survey during the field season, preparing his report in the winter. Another assistant geologist was elected in 1876 professor in another college, and accepted the chair on condition that he should have the freedom of the field season. The mineralogist of the survey was a professor of chemistry in the University of Pennsylvania, and performed his duties to the survey in the laboratories of the university, and was allowed (after 1875) an aid in said work. The State geologist was himself professor of geology in the university until 1878, when he resigned his chair to devote himself exclusively to the survey. A number of the aids were graduates of his department, and three of them became assistant geologists on the survey. To this fact is partly ascribable its always excellent *esprit du corps.*

Salaries.—The scale of salaries proposed by the State geologist and adopted by the board ranged from $3,000 for the State geologist, $2,500 for the chemist, $2,000 and $1,600 for assistant geologists, down to $1,200, $900, $720, $600, and $480 for the aids, a year; in all cases exclusive of traveling and other necessary expenses. Instruments and stationery, expressage, and postage were provided by the survey. All salaries and bills of expense were settled, to the last day of each month, by drafts of the State geologist on the treasurer of the board, audited by a committee of the board at each quarterly meeting. Duplicate vouchers were filed in the office of the auditor general of the State.

Appropriations.—The survey was sustained by specific appropriations made by the legislature at its biennial session, as follows: By the act approved May 14, 1874, $105,000; May 13, 1876, $65,000; April 18, 1877, $100,000; June 11, 1879, $50,000; May 26, 1881, $125,000; June 28, 1883, $50,000; July 3, 1885, $50,000; 1887, $88,000; 1891, $10,000; total, $643,000. Of this amount $495,000 was expended between May, 1874, and July, 1885; or an average of $45,000 a year for 11 years.

The amounts proposed to be disbursed by the State geologist were submitted in estimate at the quarterly meetings of the board of commissioners, and approved or modified. The amounts actually disbursed were reported to the board, the vouchers audited by a committee and deposited in duplicate with the auditor general of the State.

Personnel.—The personnel of the survey from 1836 to 1854 has been described and published in report A, first part, 197 pages, octavo, 1876, entitled "Historical Sketch, etc."

From 1874 to 1886 the personnel of the survey was as follows, the × under the several dates showing the years or parts of years during which the persons named (in alphabetical order) were employed on the survey in various capacities and districts:

	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886
Adachi Jinzoo......	......	......	......	......	......	......	......	......	......	......	×	×	×
Aquirré, A. A.[1]......	......	......	×	×	......	......	......	......	......	......	......	......	......
Albright, C. E......	......	......	......	......	......	......	......	×	......	......	......	......	......
Albright, H. F......	......	......	......	......	......	......	......	......	......	......	......	×	×
Allen, Charles *......	×	×	×	×	×	×	×	......	......	......	......	......	......
Ames, C. W......	......	......	......	×	×	×	......	......	......	......	......	......	......
Ashburner, Charles A.*......	×	×	×	×	×	×	×	×	×	×	×	×	×
Beecher, C. E.[2]......	......	......	......	......	......	......	......	......	×	......	......	......	......
Berlin, A. P......	......	......	×	×	×	×	......	×	×	×	......	......	......
Billin, C. E......	×	×	×	×	×	×	......	......	......	......	......	......	......
Branner, J. C......	......	......	......	......	......	......	......	......	......	×	×	×	......
Carll, J. F.*......	×	×	×	×	×	×	×	×	×	×	......	×	×
Chance, H. M.*......	×	×	×	×	×	×	×	×	×	×	×	......	......

[1] Special draftsman for parts of two years.

[2] Special draftsman for part of a year (fossils).

* Authors of reports.

	1874	1875	1876	1877	1878	1879	1880	1881	1882	1883	1884	1885	1886
Clark, Ellis, jr	×	×	×										
Claghorn, R. C											×	×	
Claypole, E. W.*								×	×	×			
Carraher, M					×	×	×	×	×	×	×	×	×
Chapman, M							×	×					
Christian, G. H	×	×											
Dager, J. H			×										
Dewees, J. H.*	×	×	×	×	×	×							
d'invilliers, E. V.*						×	×	×	×	×	×	×	×
Eakins, L. G								×					
Edwards, J. W	×	×	×										
Ewing, A. L.[1]										×			
Fagen, H. J	×	×											
Fellows, W. A					×	×							
Flick, W. J								×					
Ford, S. A		×											
Forman, F. W	×	×	×	×	×	×	×	×	×	×			
Frazer, Persifor *	×	×	×	×	×	×	×						
Fuller, J. T						×							
Genth, F. A.*	×	×	×	×	×	×	×	×	×				
Griffith, William										×			
Halberstadt, B								×	×	×	×	×	×
Haldeman, B. F									×				
Hale, A	×	×	×	×	×								
Hall, C. E.*		×	×	×	×	×	×	×	×				
Harden, E. B.*	×	×	×	×	×	×	×	×	×	×	×	×	×
Harden, O. B		×	×	×	×	×	×	×	×	×	×	×	×
Hartranft, S. S					×	×							
Hartshorne, J			×	×	×								
Hatch, F. A	×	×											
Hill, F. A.*								×	×	×	×	×	×
Hunt, T. S.*[2]		×											
Kada, Teichii									×	×			
Lehman, A. E	×	×	×	×	×	×	×	×	×	×	×		
Lehman, G. M											×	×	×
Lesley, Joseph[3]							×						
Lesley, J. P.*	×	×	×	×	×	×	×	×	×	×	×	×	×
Lesquereux, L.*		×	×	×	×	×	×	×	×	×		×	
Lewis, H. C.*							×	×					
Lyman, B. S.[4]											×		
Mansfield, I. F.[5]				×									
McCreath, A. S.*	×	×	×	×	×	×	×	×	×	×			
McCreath, D			×	×									
Merkle, J. F												×	
Miner, Charles											×		
Morris, G							×	×					
Moyer, H. I							×	×	×	×			
Nettleton, E. S.[6]				×									
Parrish, H. E								×	×	×			
Platt, Franklin *	×	×	×	×	×	×	×	×					
Platt, W. G.*		×	×	×	×	×	×	×					
Prime, F., jr.*	×	×	×	×	×	×	×						
Randall, F. A.[7]						×							
Sadtler, S. P.*		×	×		×								
Sanders, R. H.*	×	×	×	×	×	×	×	×	×				
Scott, C. B								×	×	×	×		
Sheafer, A. W.*						×	×	×	×				
Sherwood, A.*		×	×	×	×								
Simpson, G. B.[8]											×		
Sims, H. N									×	×	×	×	
Smedley, J. H.[9]								×					
Smith, A. D. W										×	×	×	×
Somerville, B												×	
Stinson, J. M	×	×	×	×	×	×	×	×	×	×			
Stevenson, J. J.*		×	×	×	×			×	×				
Stockton, N. A						×							
Wall, J. S.*											×		
Wells, Bard								×	×	×	×	×	
White, I. C.*		×	×	×	×	×	×	×	×	×	×		
Williams, T. J										×	×		
Winslow, A									×	×	×		
Wright, G. F.*[10]									×				
Wrigley, H. E.[11]	×	×											
Young, C. A	×	×	×										

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[1] Special report on fossils of Center County.

[2] Special report E.

[3] Special assistance in indexing.

[4] Special survey along the Connodogwinit Creek.

[5] Special collection of coal plants.

[6] Special oil-well records.

[7] Special report on Warren section and fossils.

[8] Special draftsman (fossils).

[9] Special notes on serpentine localities.

[10] Special survey of parts of the Glacial Moraine.

[11] Special report J.

* Authors of reports.

Progress.—In 1874 the survey was begun in Venango and Butler, in Clearfield and Jefferson, in Mifflin and Huntingdon, in York and Adams, and in Lehigh Counties.

In 1875 it was continued in those counties and was begun in Greene, Washington, and Allegheny, in Cambria and Blair, and in Tioga and Bradford. A special survey of parts of Clinton was also made.

In 1876 the survey of the oil region was made to include parts of Warren and Crawford, Clarion and Armstrong. The rest of Allegheny was surveyed, half of Westmoreland and Fayette, all Beaver, half of Butler, all Somerset, Potter, and part of Snyder, and the survey of McKean was begun. The Lehigh work was extended into Northampton and Berks, the York and Adams work into Franklin and Cumberland.

In 1877 the survey of the oil region and that of McKean were continued; Westmoreland, Fayette, and Butler were finished; Lawrence, Indiana, Lycoming, and Sullivan surveyed; the Blair County topographical survey extended; the South Mountain topographical survey continued; the Northampton mountain and valley topographical survey extended into Berks; the survey of Juniata begun; the topographical survey of the Seven Mountains in Snyder begun; the survey of Elk, Cameron, and Lancaster counties begun; and the outcrops of southern Bucks and Montgomery mapped and specimens collected.

In 1878 the survey of the oil region was continued; Mercer, Clarion, and Armstrong surveyed; McKean completed; Potter revised; Juniata revised and Perry surveyed; mapping in Blair finished; mapping of the Seven Mountains continued; mapping of the South Mountains continued; mapping of the Reading mountains continued; Lancaster completed; southern Bucks and Montgomery mapped; and the museum arranged and catalogued.

In 1879 the survey of the oil regions was continued; Crawford, Erie, Jefferson, and Clinton were surveyed; the Elk and Cameron survey was extended into Forest, and the work in all three counties completed; the Franklin County valley was surveyed; the South Mountain topography continued; the Reading Mountain survey extended westward; the survey of the Philadelphia belt extended into Delaware County; and Chester County surveyed.

In 1880 the survey of the oil region was continued; the Coal Flora (collected, studied, described, and figured by Mr. Lesquereux since 1874) was published; the descriptions of the coal plants of Greene County were published; the subject of waste in anthracite coal was studied; Susquehanna and Wayne Counties were surveyed; the South Mountain topography was continued; the Cumberland County valley was surveyed; and the study of anthracite geology and mining methods begun.

In 1881 the survey of the oil region was continued; Warren was surveyed: Pike, and Monroe, and part of Carbon were surveyed; a special paleontological survey of Perry and Juniata was begun; and a systematic mine and surface survey of all the anthracite coal fields was organized.

In 1882 the anthracite survey was carried forward; Center, Dauphin, Lebanon, Luzerne, Lackawanna, Columbia, Montour, and Northumberland counties were surveyed; the Perry County paleontology continued; the third and last volume of the Coal Flora published; the Report on Methods of Coal Mining completed; and the first sheets of the Anthracite Survey published. A special survey along the Lehigh River was begun.

In 1883 a special survey of the Monongahela River collieries was made; the Clearfield County coal fields were resurveyed; Huntingdon County was finished; the roofing-slate belt in Northampton, Lehigh, and Berks was surveyed: the glacial moraine was traced across the State: the survey of the anthracite fields was continued. additional sheets published, and a special topographical survey of the Wyoming coal field commenced. The hand atlas of counties was prepared for publication.

In 1884 the anthracite surveys were continued, and some unfinished work in other parts of the State undertaken.

In 1885 there remained still unaccomplished a necessary revision of parts of Forest, Tioga, Bradford, Union, and Snyder, and of the whole of Juniata; a survey of the Pinegrove-Orwigsburg Valley; some special local surveys in Cumberland, Dauphin, Lebanon, and Bucks; a systematic survey of the Mesozoic country in Berks, Montgomery, and Bucks, and some important local surveys in Chester and Delaware, before the final preparation of the remaining volumes of county reports could be published.

As the appropriation of 1885 was reduced to about one-half, and as a new survey of the oil, gas, and bituminous coal region of the western counties was called for by the act, the things above mentioned had to be postponed and a new disposition of the force of the survey made. The operations of the anthracite work had to be restricted within narrower limits and several of the assistants resigned.

In 1886 the anthracite survey was continued; the gas wells were studied; a more detailed survey of the anticlinal and synclinal structure of the Pittsburgh coal fields made; special features of the Cumberland Valley studied; the maps of the water department of Philadelphia used for differentiating the Trias across the interval between the Delaware and Schuylkill Rivers; collections made from the Silurian limestone beds on the Schuylkill for microscopic examination:

a section along the Lehigh River finished; and a study made of the collection of invertebrate fossils.

Several large maps of the eastern and western counties were published this year, and a considerable number of new mine sheets, cross section, and columnar sheets of the anthracite field.

Publications.—The publications of the survey have been as follows, all in octavo:

1875, six volumes, B, D, H, I, J, M; 1876, four volumes, A, C, K, L, and a pamphlet B^2; 1877, five volumes, C^2, H^2, H^3, I^2, K^2; 1878, nine volumes, D^2, E, F. G, H^4. K^3. N. O. Q; 1879, three volumes, M^2, Q^2, V; 1880, 12 volumes, C^3, G^2, G^3, G^4, H^5, I^3, O^2, Pi, ii, P^2, Q^3. R, V^2; 1881, six volumes, A^2. G^5, H^6, M^3. Q^4, T; 1882, three volumes, C^6, G^6, T^2, and atlas (AA)1; 1883, seven volumes. AA, AC, C^4, D^3 (1), D^3 (2i), G^7, I^4, and atlas D^5; 1884, six volumes, H^7, K^4, Piii, P^2, T^4, Z, and atlas (AA)2; 1885, six volumes, AA^2i. C^5, F^2, R^2, T^3, X, and atlases (AA)3 (AA)4. In 11 years the survey has published 67 volumes, octavo and one pamphlet, 4 anthracite atlases, and nine other atlases to volumes AC, C^3, D^3, D^5, I^3, P, R, R^2, and T.

It has published colored geological maps of 57 out of the 67 counties; colored maps of Cambria, Somerset, Juniata, Mifflin, Snyder, Union, Schuylkill, Berks, Montgomery, and Bucks being still unpublished; but uncolored geological maps of Cambria and Somerset are included in their volumes; and colored maps of the eastern half of Berks and of the southern parts of Montgomery and Bucks have been published in advance. All the county maps are on the scale of two miles to the inch except McKean County and Philadelphia, which are on a scale of one and one-half miles to the inch. Colored geological maps of all the counties, on a scale of six miles to the inch, prepared by the State geologist at various stages of the survey, will be found in the hand atlas (X) published in 1885.

All the volumes of reports, with three or four exceptions, are illustrated with diagrams, sections (columnar and horizontal), sketches made in the field, local maps, and photographic views of such important outcrops as could not otherwise be described with requisite accuracy, amounting in all to several thousand.

There was published in 1886 one volume octavo and an atlas; the annual report for 1885; the first of its kind, including all the reports of assistants presented for that year. A similar annual report for 1886, went to press in time for distribution early in 1887.

The distributions of the publications of the survey by the board of commissioners was regulated for 10 years—that is, from 1875 to 1885—by section 10 of the act of May 14, 1874, which ordered that copies should be donated to all public libraries, universities, and colleges in the State, and should be furnished at cost of publication to other applicants; the money received therefor being covered back into the State treasury.

It was supposed that, by this proviso of the act, every citizen of the State who really valued a report would be easily able to obtain a copy, while no copies would be wasted, as by a free distribution. But, in point of fact, there was little or no sale, because citizens of the State were accustomed to obtain from their representatives and senators, without cost, all other State documents.

Consequently, when, in 1875, Report B, on the Mineralogy of the State, and Report J, on Petroleum, appeared, and a popular demand for copies of them was made on the members of the legislature, who could not furnish to their constituents what they had to purchase for themselves, an act was passed providing for a special edition of 5,000 copies of each one of these reports, for the use of the senate and house of representatives. Similar acts were subsequently passed by the legislatures of 1877, 1878, and 1879, respecting all the reports.

Under these acts, 425,931 copies of geological reports were printed for members of the legislature and distributed by them among their constituency. In addition to this, and under the organic law of the survey, the board published 110,569 copies, part of which were distributed to public libraries, universities, and colleges in the State, and the remainder held at sale at cost. But the sale of reports was almost wholly stopped by the free distribution of the special legislative editions; so that in 1885 there still remained unsold 43,118 copies.

In view of this fact an act was passed and approved by the governor, July 3, 1885, the first section of which enacted:

> That the board of commissioners of the geological survey are hereby authorized and directed to distribute the remaining copies of said reports as follows: Fifty copies of each report to the State librarian for distribution and exchange with other States and Territories, and of the balance an equal number of volumes to each member of the present senate and house of representatives, making the sets complete, as far as practicable.

The board, before acting under this law, submitted the same to the attorney general of the State, and in accordance with the interpretation of the act received from the department, the stock of reports was distributed as follows:

Copies retained for distribution to public libraries, universities, and colleges in the State, under the act of May 14, 1874	6,132
Copies (50 sets) delivered to the State librarian	3,600
Copies delivered to the senate librarian for distribution to the senate	7,040
Copies delivered to the resident clerk of the house of representatives, for distribution to the members of the house	26,162
Copies mislaid and discovered after distribution had been made	61
Copies damaged	123
Total	43,118

The publication of the later reports was regulated by section 2 of the act of July 3, 1885, which reads as follows:

> That of each report hereafter published, 3,500 copies shall be printed, which shall be distributed by the board of commissioners as follows: Five hundred copies to the senate; 2,000 copies to the house of representatives; 150 copies to the State geologist, out of which he shall donate copies to authors and to members of survey corps as heretofore granted; 600 copies to the board of commissioners for distribution to public libraries, universities, and colleges in the State, to parties rendering material assistance to the survey, and for exchange with foreign societies and geologists; and 50 copies thereof to the members of the board; 100 copies to the secretary of internal affairs, for distribution by him; 100 copies to the governor, for distribution by him; and 50 copies to the State librarian, for distribution and exchange with other States and Territories.

The edition of the hand atlas was limited to 1,000 copies.

Benefits and results.—A special character has been impressed upon the Pennsylvania survey by several facts of dominant importance:

1. The Paleozoic formations reach their maximum thickness in this State: and consequently admit of a greater differentiation than elsewhere into special groups of beds.

2. The middle region of the State is magnificiently plicated and eroded, exposing innumerable outcrops, connected in zigzags, and of immense length.

3. No unconformable later deposits cover and conceal these outcrops, so that there is an unexampled opportunity for the study of variable thicknesses and changes of type.

4. The topographical features are so dependent upon the lithology and structure that any geological survey of the region must be virtually a topographical survey.

5. The geological areas are of great size and so clearly defined and so distinct in character that they naturally claimed and received each one a survey of its own. These areas are: 1, the bituminous coal field of the west and north; 2, the anthracite coal fields in the east; 3, the middle belt of Devonian and Silurian formations; 4, the Mesozoic belt of the south and east; 5, the South Mountain azoic; 6, the Philadelphia belt of azoic rock: and 7, the region of glacial drift.

6. The natural section of the bituminous coal measures, down the Monongahela and up the Allegheny Rivers, relieved the study of that part of the Paleozoic system of all ambiguity.

7. The great amount of mining done in the anthracite fields made that part of the survey peculiarly exact and correct.

8. The great size and number of the brown hematite mines furnished unusual opportunities for the study of that kind of mineral.

9. The great size and number of limestone quarries, exploited for the manufacture of iron, and for fertilizing farms, opened to view every part of the great Siluro-Cambrian formation, the whole of the Lower Helderburg, all the Devonian and most of the Carboniferous limestone beds.

10. On the other hand, Pennsylvania is singularly destitute of workable veins of the precious metals. Its poverty in gold, silver, copper, and lead is extreme. It has but one important zinc deposit and but one nickel mine. In fact, its azoic regions as a whole are barren country, containing but a few small magnetic iron ore beds, in strong contrast to the adjoining azoic region of northern New Jersey. What little white marble it possesses makes a narrow outcrop for a few miles along a single line. Some serpentine rock, a little chrome iron, one large soapstone quarry, and some kaolin deposits, conclude the list of its azoic minerals.

Practically viewed, the geology of Pennsylvania is wholly Paleozoic, on the most magnificent scale, with an unexampled wealth of anthracite and bituminous coal, brown hematite iron ore, limestone, rock oil and rock gas; and to the study and description of these its geological survey has from first to last been devoted.

Little attention has been paid to the lithological study of the building stones of the State, or to their economic description. The entire State is a rock quarry. Every known building stone from the granites, gneisses, quartzites, and traps, to hearthstones, flagstones, brownstone, and limestone can be got with ease, and in infinite abundance on lines of transportation. All the principal outcrops of these building stone formations have been located and their places in the Paleozoic series defined in the reports, with sufficiently precise descriptions of their qualities and uses; but beyond this the survey could not go.

The paleontology of Pennsylvania was almost entirely neglected by the survey of 1835–1841, and that of 1851–1854. A considerable collection of fossils was made during the first term, but they were not studied; with the exception of the coal plants, resulting in the important report of Leo Lesquereux, embodied in Prof. H. D. Rogers's final report of 1858. The text of this report[1] was illustrated by 23 quarto plates of figures.

The absolutely practical spirit of the Pennsylvania survey is manifested by the fact that the study of these vegetable forms was prompted by the hope of making them useful as characteristic features of the separate coal beds, enabling the coal men to identify their favorite beds at different collieries and in different basins. This hope proved fallacious; but when the survey was resumed in

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[1] Geology of Pennsylvania, vol. 2, pp. 835 to 884.

1874 Leo. Lesquereux was commissioned to repeat and extend this investigation from year to year. In 1880 the first and second parts, and in 1884 the third and last part of his Coal Flora were published. in 980 pages, octavo, of text and 111 double-page plates of figures.

In the final report of 1858, Professor Rogers gave 20 quarto pages (vol. 2, pp. 815 to 834) to a chapter on organic remains of the Paleozoic strata of Pennsylvania, with 90 good woodcut figures of algae and mollusks. characteristic of the 13 formations; an average of seven species to each formation. The contrast between this and the numerous volumes of text and plates published by the New York Geological Survey was sufficiently striking, and produced a general impression upon the minds of paleontologists that while the thin northern outcrops of Silurian and Devonian rocks in New York and Canada were extraordinarily rich in organic forms, their vastly thicker southern outcrops in middle Pennsylvania were extraordinarily barren of remains. But in fact all the energies of the Pennsylvania survey were insufficient to cope with its structural and economical problems; and it was with the sincerest satisfaction and without a trace of jealousy that the Pennsylvania geologists saw themselves in good measure exonerated from the additional task of paleontological field work, feeling how completely it was being done for them by the able geologists and the great paleontologist of the State of New York, whose volumes were as available as if they had been based on collections made in Pennsylvania.

In a purely scientific sense this tacit mutual arrangement is now seen to have been a little unfortunate, as it fixed on American paleontology certain dogmatic determinations of time-order, which a thorough scrutiny of the southern outcrop belt carried on *pari passu* with that of the northern outcrops, would have modified. But, after all, no real harm was done; and at all events no other course was left open to the earlier surveys of Pennsylvania. Even when the survey was reorganized in 1874, and for some years afterwards the same arrangement had to be renewed; although an attempt was made to handle the collections as they came in to headquarters, and a paleontological assistant was commissioned as curator of the museum. But his attention was soon diverted to the urgent study of the mysterious azoic belt in the southeastern corner of the State; while the whole force of the survey had to be expended upon a revision of the structure and economics of the counties. The survey, if not practical. would not have been continued by successive legislatures. Paleontology was again sacrificed to structural and chemical geology, to mapping and sectioning. and outcrop tracing.

The only paleontological work done from 1875 to 1880 was that of Prof. J. J. Stevenson and Prof. I. C. White along the West Virginia, Ohio, and New York borders. But in 1881, 1882, and 1883, Professor White paid especial attention to the fossils of the middle belt of counties on the Delaware, on the Susquehanna, and on the upper Juniata Rivers, his results being embodied (without figures) in his reports; Professor Stevenson did the same on the Maryland border; and Professor Claypole was commissioned in the same three years to prepare a special report of all the forms discoverable in the rich district of the lower Juniata. A slight sketch of his results is given in the preface and sufficiently full descriptions of the fossil horizons in the text of his report F–2 on Perry County. Generic and specific descriptions and figures have not been published. Enough has been done, however, to make the published paleontology of New York available in Pennsylvania.

The great want of the survey is a proper habitation, where its large collections, now stored in the cellar of the Academy of Natural Sciences, can be handled, discussed, and placed on exhibition for the instruction of the public, and especially of the teachers of public schools and academies during their summer vacations. In such a building the models of surface relief and of underground structure made by the survey, as well as the contoured and colored topographical and geological maps would be on permanent exhibition; while many others might be added to the collection.

Several of these models deserve mention, or are unique of their kind. One exhibits the plicated structure of the southern anthracite coal basin from the Little Schuylkill at Tamaqua to the Lehigh River at Mauch Chunk. Another like it exposed to view the underground structure of the mammoth coal bed of the western middle anthracite field, east and west of Mahanoy City.

These models are not mere rough illustrations of the way in which the coal measures of eastern Pennsylvania are folded, faulted, and overturned, and of the kind of difficulties characterizing colliery practice. They are accurate exhibitions of the precise height, length, breadth, and shape of the anticlinals and synclinal crimples which together make up the coal basins studied by the survey. They were constructed from parallel cross-sections through all the collieries, on the same scale vertical and horizontal to avoid distortion; and they carry the surveyed structure from colliery to colliery, through intervals of unworked ground sufficiently small to make important errors practically impossible. Consequently the structure ahead of the workings can be predicted with a fair approach to nicety; and such measurements may be made to changes of dip, overturns, faults and other troubles, as may advantageously modify the plans of superintendents in advance. If the survey is continued every basin of the anthracite region will be not only mapped but modeled in this manner for the use of miners. The floor of the principal bed worked in each district is taken for the surface of the model.

The purely scientific value of these models and of the underground contour-line maps which accompany them is considerable; for until they were made very crude and incorrect views of the complicated structure of each basin were entertained even by those best acquainted with it; and a large step has been thus made in the theory of plication.

To carry the theory one stage further a large model (2 feet by 4 feet) has been made of the uncovered surface of the Medina formation, No. 4, over an area of about 40,000 square miles; that is, from the Maryland and West Virginia State line to southern New York and northern New Jersey; in other words, from the Blue Ridge-South Mountain range, across the plicated middle belt of the State, into the slightly waved country north and west of the Allegheny Mountain. The scale adopted, vertical and horizontal the same, is 3,000 feet to 1 inch. The surface of the Medina Sandstone where erosion has spared it is laid bare; and where erosion has gone deeper into the lower Silurian formations, the Cambrian and Archean rocks, a restoration of all up to the top of the Medina has been made, based upon the graphic projection of the curves over the grand anticlinals. This model was made in 1884, but has not been published, because its southeastern border was not satisfactory; but the light which it has thrown on Appalachian structure at large is extraordinary; especially as to the kind, direction, and degree of the sidethrust northwestward, and the relationship of the anthracite region to the South Mountain masses.

Recently a local and more accurate model has been made of the district of the Seven Mountains near the center of the State, to show the hunching of one of the great synclinals at one stage of its course across the State. The scale of this model (vertical and horizontal) is 3,200 feet to 1 inch.

Similar models of the bituminous coal basins of the Pittsburgh district and of the oil-sand group of the western counties, will show by the uncovered surfaces of the Pittsburgh bed and the first oil sand, the general slope to the southwest, and their rise and fall over the anticlinals.

The topographical maps of the survey are large and elaborate, and embody the results of years of instrumental work. The field work was plotted on a scale of 400 feet to 1 inch, and reduced for publication to 1,600 feet and 3,200 feet. The first accomplished was a map of the limonite-bearing lower Silurian region of Blair and Huntingdon Counties, extended to the coal measures at the crest of the Allegheny Mountain. The second finished and published map embraces the South Mountains of Berks, Lehigh, and Northampton counties from the Schuylkill to the Delaware, and includes the border of the Trias on the south, and the limestone region of the great valley on the north, with all its iron ore mines. The third, partly published and nearly finished, covers the South Mountain region from Harrisburg to the Maryland line; but its geology is still to be worked out.

Numerous local maps of the same character, instrumentally surveyed, in various parts of the State, will contribute their quota to a future complete relief map of the State. An important and large addition of these data has been made by the water department of Philadelphia, under Colonel Ludlow. It is an extension of the survey map of the South Mountains, southward over the Trias region of Bucks and Montgomery, toward Philadelphia. With this map in hand the survey can now work out the geology of the New Red Belt between the Schuylkill and Delaware Rivers, in a tolerably satisfactory manner. But the whole belt must be thus mapped before some of the paradoxical exhibitions of this interesting formation can be thoroughly well understood.

As for the azoic belt of the southeastern corner of the State, from Trenton, past Philadelphia and West Chester into Maryland, especially that part of it west of the Schuylkill, it seems hopeless to unravel its structure before a complete and accurate relief of the survey, in the minutest detail, has been obtained. No general survey of it avails. Several years of hard work has been expended upon it, but the geology remains as obscure as ever. Two local relief maps only have been made, which reveal important facts, and show what may be expected from this kind of work wherever it shall be faithfully done. But the Philadelphia azoic belt will continue to be the *pons asinorum* of Pennsylvania geology for years to come. Appalachian geology is child's play compared with it.

All field work of the second survey closed with June 1, 1890, after which date work was continued for the completion of its publications, chiefly the last sheets of the anthracite survey, the maps and sections of the survey of the new red belt of Bucks and Montgomery counties, the completion of the bituminous colliery, map of western Pennsylvania, a new geological State map,[1] and the three volumes of the final report. Of the latter, volumes 1 and 2 were prepared in person by Lesley, and some 200 pages of part 1 of volume 3. Failing health compelled him to relinquish the work at this point, and it was completed by E. V. d'Invilliers and A. D. W. Smith. Volumes 1 and 2 appeared in 1892 and volume 3 in 1895. They comprise 2,638 octavo pages of text and 611 plates.

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[1] Vol. 1 of Final Reports, Geological Survey of Pennsylvania, 1892, p. 3.

In 1889 the matter of a State survey was again revived through an act of the legislature entitled "An act to authorize the topographic and geologic survey of the State in cooperation with the United States geological survey." This act is still in force. (See Bulletin 465, U. S. Geological Survey, p. 124.)

RHODE ISLAND.

At a meeting of the " standing committee of the Rhode Island Society for the Encouragement of Domestic Industry, holden on the 26th day of December, A. D. 1838," the following resolution was adopted:

> *Resolved*, That Messrs. John Pitman, Joseph Mauran, Christopher Rhodes, and Owen Mason be a committee to memorialize the general assembly, and to confer with such committee as the general assembly may appoint, to inquire into the expediency of authorizing a geological and agricultural survey of this State, and to adopt such other measures as they may deem expedient to carry the same into effect; and that the sum of $500 be appropriated by this society in aid of this object: *Provided*, The State shall, at the ensuing January session, appropriate the residue of the sum necessary for the purpose, and take measures to carry the same into effect, under the immediate supervision of the State or of this society.

It was presumably in accordance with the memorial presented by this committee that the appended resolution was passed by the assembly the following year:

> *Resolved*, That the sum of $2,000 be appropriated and paid from the general treasury to defray the expenses of a geological and agricultural survey of the State.
>
> *Resolved*, That the same be expended under the direction of Messrs. King, Simmons, Potter, of South Kingstown, Rhodes, and Luther, with such as the honorable senate may add, who are hereby appointed a committee for that purpose, to serve without compensation, which committee are authorized to draw upon the treasury for such sum or sums as may be necessary, not exceeding in the whole the aforesaid sum of $2,000.
>
> *Resolved*, That said committee be authorized to act in conjunction with any committee that may be appointed for the same purpose by the Rhode Island Society for the Encouragement of Domestic Industry.

In accordance with this enactment a contract was entered into with Dr. C. T. Jackson, in April, 1839. In May, 1840, the manuscript of his report was submitted for publication. It does not appear that he was assisted in any way other than by volunteers.

From an examination of the report it appears that Jackson made long excursions out of Providence, visiting the principal towns and traversing the important rock groups so as to attain general cross sections of the area.[1]

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[1] J. W. Woodworth, American Geologist, August, 1897.

His report, an octavo volume of 312 pages, with a colored geological map of the State, appeared in 1840. The printing and distribution of the same was provided for by the following resolution:

In general assembly, May session, A. D. 1840.

The committee appointed to procure a geological and agricultural survey of the State, having accomplished the same, and having received from Dr. Charles T. Jackson, the geological and agricultural surveyor, a satisfactory report:

Resolved, That the said committee be, and they are hereby, authorized to cause 1,000 copies of the report of said survey to be printed and bound; and that the said copies when finished be distributed in the following manner, viz: One copy to his excellency the governor; one to his honor the lieutenant governor; one to each of the present members of this general assembly; one to the supreme executive of each of the United States; one to the town clerk of each town in this State; one to each school district in this State, excepting the districts in Newport and Providence; 20 copies to the town of Newport, and 30 copies to the city of Providence, which said copies shall be distributed in said Newport and Providence by the school committees therein; one copy to each public library in the State; one to the Rhode Island Historical Society; one to Brown University; five copies to the Library of Congress; and the residue to be deposited in the secretary's office.

No further steps toward a survey of the State appear to have been taken until 1875, when the following resolutions were passed:

Resolutions authorizing the governor to appoint commissioners to prepare a plan for a thorough geological and scientific survey of the State.

Resolved, That the governor be authorized to appoint five competent persons, two of whom may be nominated by the Providence Franklin Society, a commission to prepare a plan for a thorough geological and scientific survey of the State, to make an estimate of the expense thereof, and to report thereon to the next general assembly, if possible, at its May session.

Resolved, That the members of the commission thus appointed shall serve without compensation, but their traveling and other expenses incurred in the performance of their duty as such commissioners shall be paid from the treasury of the State.

Resolved, That the sum of $500 is hereby appropriated for the use of said commissioners, and the governor is authorized to draw his order on the general treasurer for the same, upon requisition of the chairman of the commission.[1]

In accordance with these resolutions a committee was appointed, consisting of Zachariah Allen, William F. Channing, George I. Chace, John R. Leslie, and George F. Wilson. Sundry meetings were held by this committee and a report comprising some 13 octavo printed pages submitted to the assembly in January, 1876. A survey was recommended and the following plan for its consummation presented:

1. A board shall be appointed having permanent charge of the scientific survey of the State.

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[1] Report of the Rhode Island Commission to prepare a plan for a thorough geological and scientific survey of the State. January, 1876, p. 3.

2. The sum of $20,000 shall be appropriated for the geographical survey of the State, in four equal annual installments of $5,000 each, to be expended under the direction of the board of survey, provided that the board shall contract with a capable and responsible person to complete the topographical plane-table survey of the State on the coast survey standard and scale of field work, as described, for a sum not to exceed $20,000, and also provided that the United States Coast Survey will furnish the requisite triangulation.

3. A map of the State, on a scale of $\frac{1}{40000}$, shall be published by the board on the completion of the geographical survey.

4. A geological survey of the State shall be made after the geographical survey, under the direction of an able geologist, appointed by the board. The details of the plan of the geological survey shall be decided hereafter by the board.

5. A compilation of the natural history of the State shall be the subject of recommendation to the general assembly by the board on the completion of the geological survey.

6. The board shall report annually to the general assembly.

Nothing seems to have come from this, and no survey under State auspices has since been made, although Governor Brown, in his message of 1885 to the general assembly, commended a plan for a topographic survey in connection with the United States Geological Survey, with an expenditure of $3,000 a year for two years. In 1887 Governor Wetmore called attention to the value and importance of a geological survey, but nothing was done beyond the publication by the Franklin Society of Providence of a pamphlet of 130 pages, containing a bibliography of publications relative to the geology and mineralogy of the State and a list of its minerals, rocks, and fossils.

In 1895, in response to the popular demand for improved roads, there was passed by the assembly the following resolution:

> *Resolved*, That Messrs. Walter A. Read, of Gloucester, and John Carter Brown Woods, of Providence, on the part of the senate, and Messrs. William H. Covell, of Providence, and Ellery H. Wilson, of East Providence, on the part of the house, are hereby constituted a commission to forthwith cause a geological survey to be made of those portions of the State containing rocks adapted to road making, and the sum of $1,000, or so much thereof as may be necessary, is hereby appropriated to defray the expense of the said commission; and the State auditor is hereby directed to draw his orders on the general treasurer from time to time for the payment of the same upon vouchers approved by the governor.
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> Passed May 25, 1895.

Under this resolution Mr. Frederick P. Gorham, a graduate student in Brown University, was authorized to prepare an areal geological map and collect specimens in triplicate. I am informed

Oscar Montgomery Lieber, 1856-60

Michael Tuomey, 1848-57

STATE GEOLOGISTS OF SOUTH CAROLINA.

by Prof. C. W. Brown a considerable collection of rocks was made and one or two copies of an areal map prepared, but that nothing was published.

SOUTH CAROLINA.

In the acts of the general assembly of South Carolina, passed in December, 1824, there occurs the following under the clause making appropriations for the current year (1824):

> For the salary of the professor of geology and mineralogy, $1,000, and $500 for making a geological and mineralogical tour during the recess of college and furnishing specimens of the same.

Presumably this enactment was in accordance with some previous resolution which does not appear in the printed reports. Lardner Vanuxem, of Pennsylvania, was at this date professor of chemistry and geology in South Carolina College, but whether the appropriation was for past or prospective work is not apparent, nor is the writer able to find any record of the "catalogue of mineral specimens" referred to in the act of 1825, unless it be that of 1826, mentioned below.

On December 15 of the following year (1825) the legislative committee, to whom was referred that portion of the governor's message relating to the College of South Carolina, reported as "having considered the same" * * * and in connection with their recommendations referred to "the catalogue of mineral specimens collected by a distinguished member of the faculty under the direction of this legislature" as furnishing "the strongest assurance of his industry and science and the richness of the country he has been directed to explore." They then continued:

> Your committee are under the most sanguine expectations that the day is not far distant when the bowels of the earth will be found to contain the means of increasing the fertility of its surface; and they recommend most earnestly a continuance of these examinations, not only for the benefit of those who are to be instructed in academic pursuits, but also for the promotion of agricultural prosperity.

This recommendation was agreed to by the senate and referred to the house, which concurred, under date of December 19.

Upon Prof. Lardner Vanuxem fell the burden of a continuance of the work which, however, so far as can be learned at this late date and from existing literature, amounted to little more than an announcement of the number of species and a list of the rocks and minerals found within the State—10 species of rocks, 30 of minerals. His report (made in 1826) appears to have been originally printed in the newspapers, a reprint of unknown comprehensiveness appearing in Mill's Statistics of South Carolina, 1826 (pages 25–30), and later in Lieber's final report. Vanuxem severed his connection with the college in 1826 to undertake private mining ventures in Mexico, and nothing further appears to have been done until 1842, when the assembly committee on agriculture, after an amusingly verbose and grandiloquent preamble—

> *Resolved*, That the interests and pursuits of South Carolina are essentially agricultural and should be promoted by all practicable means within our power.
>
> *Resolved*, That a geological and agricultural survey of the State, for the examination of our soil, discovery and application of marl lime, and developing all other resources and facilities of improvement will prove among the most efficient means of giving value to her soil, increasing her products, multiplying her population, and diffusing national and individual prosperity.
>
> *Resolved*, That as a means of testing this salutary measure an annual appropriation of $2,000 be granted for two years for an agricultural survey of the State, to be prosecuted during that period; and that the governor be specially charged with procuring a competent individual to effect such survey, who shall report all geological information which may be incidentally collected on such survey.
>
> *Resolved*, That the result of each year's survey be reported to this house, and copies distributd to every agricultural society throughout the State.
>
> *Resolved*, That the house do agree to the report. Ordered, that it be sent to the senate for concurrence.

In the senate December 17, 1842:

> *Resolved*, That the senate do concur in the report. Ordered, that it be returned to the house of representatives.

Acting under these resolutions, Gov. John H. Hammond appointed Edmund Ruffin, agricultural surveyor of the State. After a year of "arduous labor" Mr. Ruffin resigned, to be succeeded on a broader platform by Michael Tuomey. Ruffin had for some years been prominent in agricultural matters, and in 1840 had "for the purpose of presenting the fullest proof in facts and opinions derived from the experience of practical men of the operations and effects of marl," published "sundry circular queries and also directed copies specially to many known individuals." The report rendered by him in November, 1843, contained the results of these queries, so far as results had been obtained, and also a dissertation on the subject of the general character, extent, and distribution of the calcareous formations of the lower portion of the State. A few pages were also devoted to the soils of the granitic region above the lower fall line and to rice culture in the Georgetown district. The report closed with a series of appendices composed of short papers connected with the report.

FIRST GEOLOGICAL AND AGRICULTURAL SURVEY UNDER MICHAEL TUOMEY, 1843-1846.

As previously noted, Ruffin, as agricultural surveyor, was succeeded in 1843 by Michael Tuomey. It does not appear from the printed records that his appointment was accompanied by any modification of the fundamental law establishing the survey, although the appropriations for 1843 were for an agricultural survey, while those of 1844, 1845, and 1846 were for a geological survey; while Tuomey's first report, dated November 25, 1844, was entitled, "Report on the Geological and Agricultural Survey." The survey under Tuomey's administration continued for three years and was supported by the annual appropriations noted.

Administration.—Mr. Tuomey was unassisted, except temporarily by volunteers. His first report (1844) contains brief papers by F. S. Holmes and Mr. Ruffin, both relating to agricultural matters. His final report (1848) likewise contained appendices by L. R. Gibbes, Robert Lebbey, T. W. Glover, and C. U. Shepard, with a reprint of Vanuxem's report from Mill's Statistics. Tuomey's salary for 1844 and 1845 was, to judge from the appropriations, $2,000, though it is apparent that this was made to cover the entire expenses of the work, exclusive of publications, which were otherwise provided for.

Expenses.—The total expenses of the surveys under Ruffin and Tuomey would appear to have been as follows:

1842, for survey	$2,000.00
1843, for survey	2,000.00
1843, for publication of report	[1] 600.00
1844, for survey	2,000.00
1844, for publication	[1] 365.78
1845, for survey	2,000.00
1845, for publication	[1] 1,000.00
1846, for survey	667.00
1846, for publication	1,000.00
Total	$11,632.78

Publications.—These consisted of Ruffin's report of 1843, Tuomey's of 1844, and his final report of 1848. I have no means of ascertaining the size of the edition.

SECOND GEOLOGICAL AND AGRICULTURAL SURVEY UNDER OSCAR M. LIEBER, 1855-1860.

In 1855 the matter of a gelogical survey of the State was again brought up through the following preamble and resolutions:

> The committee on agriculture and internal improvements, to whom was referred the memorial of sundry citizens of St. Helena Parish on the subject of

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[1] "If so much is necessary."

an agricultural and geological survey of the State, and also a resolution of the senate on the propriety of selecting a suitable person to procure and effect a mineralogical survey, respectfully report that they have considered the same and now submit the following report, with accompanying resolutions.[1]

Resolved, That this general assembly authorize the appointment of a geological, mineralogical, and agricultural surveyor, whose services shall be engaged for four years, and whose duty it shall be to explore the several districts and make a geological map, analyze minerals, ores, and manures, free of charge, and submit an annual report to the legislature for general circulation.

Resolved, That this officer shall receive a salary of $3,000; be appointed by joint resolution of the two houses; and that it shall be the duty of the joint committee of agriculture and internal improvements of the senate and of internal improvements of the house to nominate a suitable person to fill this office.

On the adoption of these resolutions Oscar M. Lieber, professor of geology in South Carolina College, was appointed State geologist, in which capacity he served until 1860. Excepting that Lieber was himself connected with the college, the survey would appear to have been an independent organization under the immediate direction of the committee on agriculture and internal improvements. It was supported by annual appropriations of $3,000 each.

Personnel.—Lieber served without scientific assistants. As noted in the resolutions he was appointed by the governor after nomination by the joint committee on agriculture and internal improvements. His salary throughout the term of service was $3,000 a year, which sum apparently covered the entire expense of the survey outside of publications. There is nothing in the wording of the act establishing the survey, or in the report to indicate that the establishment of either a museum or library was contemplated or carried out.

Expenses.—The total expense of the survey to the State would appear to be as follows:

For salary:		
1856	$3,000.00	
1857	3,000.00	
1858	3,000.00	
Total for salaries		$9,000.00
For publishing maps and plates:		
1856	1,094.50	
1857	1,400.00	
1858	700.00	
Total for publication		3,194.50
Total for survey		$12,194.50

The actual cost of printing and binding does not seem to have been provided for by special appropriation, the items mentioned above including only the cost of maps and plates. In addition to the amounts mentioned the assembly appropriated the sum of $2,000 a year for a period of four years to aid in the publication of Messrs. Tuomey and Holmes's Fossils of South Carolina, the work of preparation of which seems to have been largely, if not wholly, personal.

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[1] The report, like that of the previous committee, was unnecessarily verbose and containing nothing essential to the history of the survey, and is here omitted.

The survey reports of which there were four were distributed in accordance with the following resolutions:

Report of committee on agriculture, to whom was referred so much of the governor's message as related to the geological survey:

Resolved, That 1,000 copies of the report of Mr. Lieber, with the accompanying plates, be printed for distribution, and that the same be so printed that they may hereafter form a portion of one or more octavo volumes.

Resolved, That Mr. Lieber be entitled to receive 50 copies for distribution by himself as soon as the same shall have been printed.

From resolutions for 1857:

Resolved, That the copies of the report of the State geologist for the year 1856, which were ordered to be printed at the last session of the legislature for distribution, and now in the treasurer's office at Columbia, be disposed of as follows: That each member of the senate and house of representatives be allowed one copy, and that the remaining copies be placed in the hands of the governor, and he be requested to have deposited 12 copies in the legislative library, two copies in each college and public library in the State, and the remaining copies in the hands of the booksellers in Charleston and Columbia, and in one store at each courthouse in the State, to be sold at cost, the same commissions to be allowed them as on the statutes at large.

Be it further resolved, That in order to place the above report within the reach of everyone feeling an interest in the geological, mineralogical, and agricultural survey now progressing, that 1,000 additional copies of the above report be published in the same form and style, and be deposited with the governor, to be placed by him in the same hands for sale on the same terms.

Resolved, That 2,000 copies of the report of the State geologist for the year 1857, with the accompanying plates, be printed in the same form and style as the report for 1856, and distributed in the same manner as directed for said report.

From resolutions of 1858:

Resolved, That 2,000 copies of the report be printed; that each member of the senate and of the house of representatives be allowed one copy; and the remaining copies be placed in the hands of the governor, and that he be requested to have 12 copies deposited in the legislative library, two copies in each college and public library in the State, and the remaining copies in the hands of the booksellers of Columbia and Charleston, and in one store at each courthouse in the State, to be sold at 50 cents a copy, the same commissions to be allowed them as on the statutes at large; and they would further recommend that the copies now on hand shall be sold at a like price.

Nothing further, under State auspices seems to have been undertaken within the period covered by this history. (See further on pp. 141, 142, of Bulletin 465 of the U. S. Geological Survey.)

TENNESSEE.

FIRST SURVEY UNDER GERARD TROOST, 1831–1850.[1]

In 1831 the legislature of Tennessee took the first step toward a geological survey of the State by passing the following act:

SECTION 1. *Be it enacted by the General Assembly of the State of Tennessee.* That Dr. Gerard Troost, professor of mineralogy, geology, and chemistry in the University of Nashville, be, and he is hereby, appointed geologist and mineralogist for this State.

SEC. 2. *Be it enacted,* That the said Gerard Troost shall proceed to make a geological survey of the State of Tennessee, with a view, as far as practicable, to develop the mineralogical resources thereof, in doing of which he shall, as far as he can, examine into those mineral and metallic regions believed to exist in the different formations found in the several sections of the State, making the proper analysis of such substances as he may believe to be of value, and also to examine and be prepared to report upon the soil of different parts of the State, the rocks of those parts, with such other remarks as may lead the citizens to an estimate of comparative value and use, as well as to enable them to judge understandingly of its metals and minerals.

SEC. 3. *Be it enacted,* That the said Troost be, and he is hereby, appointed assayer of this State.

SEC. 4. *Be it enacted,* That the said Gerard Troost be allowed the sum of $500, to be paid by the treasurer of middle Tennessee, on a warrant or warrants to be drawn by the governor for the time being, in quarterly payments, when he shall be informed that the work contemplated by this act is in progress.

SEC. 5. *Be it enacted,* That said Troost shall report to the next general assembly what he may have done under the appointment as geologist as aforesaid.

December 21, 1831.

Subsequently the following resolutions relative to the survey were passed.

Resolved by the General Assembly of the State of Tennessee, That Dr. G. Troost be, and he is hereby, continued as geologist of the State of Tennessee for the next two years, with the salary already fixed by the law originally creating the office of geologist for the State.

November 15, 1833.

Resolved by the General Assembly of the State of Tennessee, That Dr. G. Troost be continued as geologist of the State of Tennessee for the next two years, with the salary fixed by the law originally creating the office of geologist for the State.

Adopted January 28, 1836.

Resolved by the General Assembly of the State of Tennessee, That Dr. Gerard Troost, geologist of the State, be requested to make a mineralogical survey and examination of that portion of the State lying within the bounds lately ceded by the Cherokee Nation of Indians to the United States, and that he report the result of his labors to the next general assembly.

Adopted October 24, 1836.

Administration.—Doctor Troost accepted the office thus tendered him, still remaining an active professor in the University of Nash-

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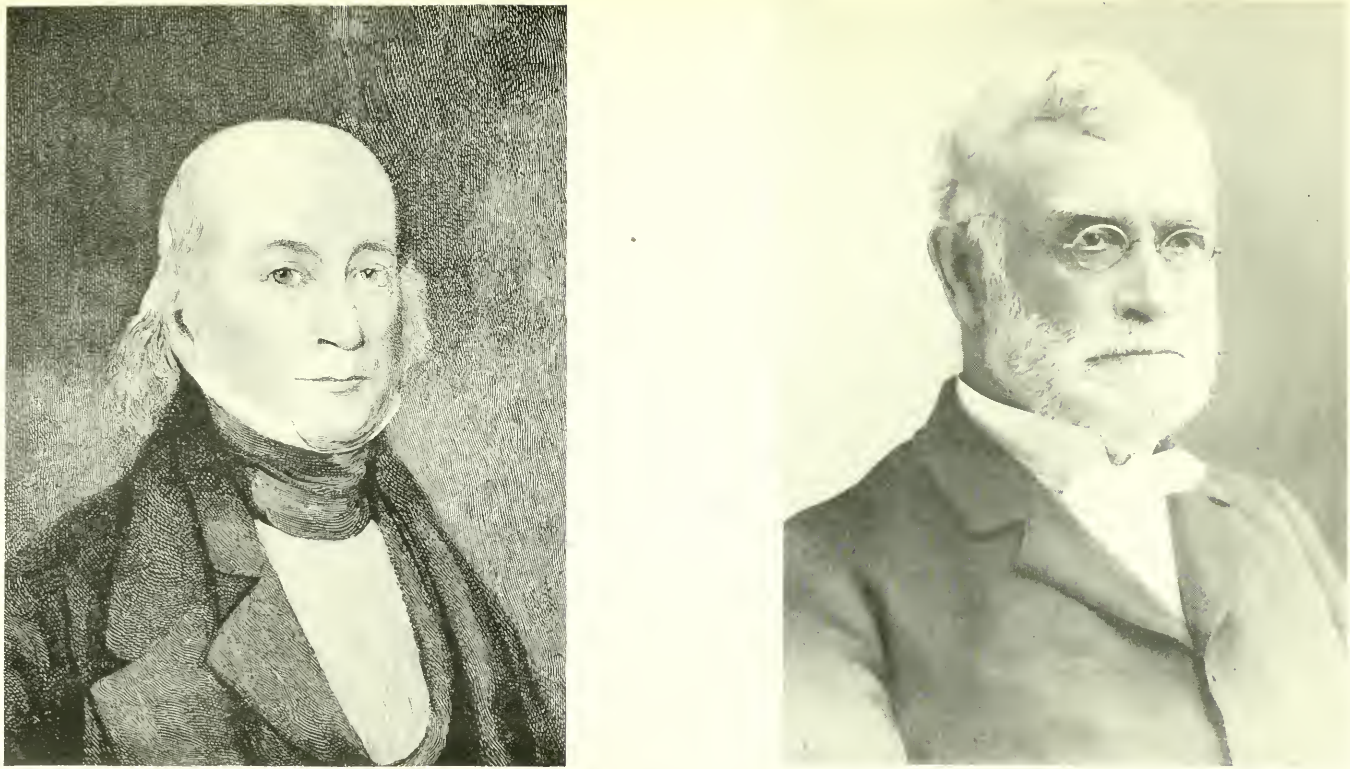
[1] Compiled mainly from manuscript notes by James M. Safford, State geologist.



GERARD TROOST, 1831-5

JAMES MERRILL SAFFORD, 1854-60, 1871-89

STATE GEOLOGISTS OF TENNESSEE.

ville. He was continued in office under biennial appointments until 1848 when the survey was discontinued. While in office he made nine reports, the first two of which do not appear to have been published. It is possible that he considered a discourse delivered in 1831, prior to the passage of the act creating the office, as his first report. The second report appears to have been made, judging from certain references to it in the legislative proceedings, on the coal measures of the State. The remaining seven reports, octavo pamphlets, have long been out of print and are rarely met with.

The third report, published in 1835 (32 pages), treats of the coal and coal formation with a fair map of the coal area of the State. the greensand of west Tennessee, followed by dissertations on marl, humus, and soils, and closes with remarks on iron ores and a list of furnaces then existing in middle Tennessee.

The fourth report, 1837 (37 pages), has 20 of its pages devoted to a general exposition of geology as then understood by the author. The latter part is an account of an excursion made by him through what was then known as the Ocoee district of Tennessee—a part of the State lying south of the Hiwassee River and east of the Tennessee. Accompanying is a geographical map of the Ocoee district, on which is a rude section of the rocks traversed. In the latter the Carboniferous formations are made unconformable with all else in east Tennessee. Closing the report is a list of fossils observed by the author in the State.

The fifth report, 1839 (75 pages), is the largest of all. It contains first a general view of the geology of the State, with a map and section, in which, by the way, not only the Carboniferous rocks, but the formations of middle Tennessee, are treated as if unconformable with the inclined strata of east Tennessee. Then follow descriptions of Cocke County, its formations, iron ores, and of a meteorite found within the limits of the county. To this succeed brief notices of other iron ores, of furnaces, a supposed silver ore, and certain mineral waters. The last 30 pages are an annotated catalogue of the fossils found in the State.

The sixth report, 1841 (48 pages), begins with a review of former descriptions of the formations of the State, in which also the application of the names Cambrian and Silurian to Tennessee formations is discussed. Then follow lists of fossils, with notes upon certain species, a notice of Sevier County, roofing slates, alum, epsom salts, nitre, iron ore, and certain mineral waters.

The seventh report, 1843 (45 pages), gives first a description of the formations of Nashville and Davidson County, with a list of minerals found at Nashville and notes on certain fossils, followed by remarks upon the formations of middle Tennessee in general, also upon iron ores, meteoric masses, and greensand. The report ends with a list of reptiles and fresh-water mollusks.

The eighth report, 1845, is short and discusses proposed routes for the Nashville and Chattanooga Railroad, especially with reference to the mineral resources of the country traversed.

The ninth report, 1848 (39 pages), describes Jefferson County, the zinc ores of the State, reduction of zinc ores, furnaces, and the manufacture of brass, concluding with analyses of zinc ores, iron ores, coal, and limestone.

A tenth report, according to Prof. L. C. Glenn,[1] was presented to the house on January 12, 1850, and 75 copies ordered printed. No regular edition was ever published, nor can the original manuscript or any of the printed copies now be found.

In addition to the above, Doctor Troost prepared a work on the crinoids of the State. He took great interest in the study of these fossils, secured a valuable and interesting collection of them, and added much to our knowledge of the group. He described many species. His manuscript, with the species old and new described and illustrated in it, was in 1851 put in the hands of Prof. James Hall for revision and publication. For some reason it was never put to press until after the death of Hall, when it was revised and published by the United States National Museum.

Expenses.—There are no data available regarding expenses nor publications other than those given above. Nine years at $500 would place the total cost at $4,500.

SECOND SURVEY UNDER JAMES M. SAFFORD, 1854–1900.

In 1848 Prof. James M. Safford, then fresh from his studies at Yale University, entered upon his duties as professor of chemistry and geology in Cumberland University at Lebanon, Tennessee. He soon discovered that the formations and structural geology of middle Tennessee had not been satisfactorily made out and that all maps relating thereto were very general and of little use. As a teacher impressed with the necessity of having some proper knowledge of the geology of the area around him, he employed his spare time in exploring the country, tracing out the formations, and collecting fossils and minerals. Vacations were given up to the work, excursions of from 100 to 500 miles being accomplished, often on foot. For this work no compensation was received from the State.

A part of the fruit of this labor was the publication in the *American Journal of Science* (vol. 12, 1851), of a map of the unique Silurian Basin of Middle Tennessee, with 10 pages of text, describing briefly the formations and giving a list of the common fossils. From the beginning thus made explorations were extended into other parts of the State.

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[1] American Geologist, vol. 35, 1905, p. 88.

In February, 1854, the legislature passed the following act creating the offices of geologist and mineralogist and assayer:

Whereas it is the opinion of this general assembly that a complete, thorough, and speedy geological and mineralogical examination and survey of this State ought to be made, and that such examination and survey ought to be made under the authority and at the expense of the State, inasmuch as it would probably result in the discovery of much wealth now hidden from the world, and thereby induce immigration to this State, enhance the price of land, and increase the public revenue: Therefore—

SECTION 1. *Be it enacted by the General Assembly of the State of Tennessee*, That the office of geologist and mineralogist of the State is hereby created: said office to be filled by the joint vote of both houses of the general assembly, and the incumbent is to continue in office for the term of two years and until his successor is elected. In case of a vacancy during the recess of the legislature the governor is to appoint a suitable person to fill said office, and his appointee is to continue in office during the unexpired term for which his predecessor was elected or appointed.

SEC. 2. *Be it further enacted*, That it shall be the duty of said geologist and mineralogist to commence and carry on a geological and mineralogical survey of the State, with as much expedition and dispatch as may be consistent with minuteness and accuracy, with a view to discover the order, relative position, and comparative magnitude of the several strata or geological formations within the State, and to discover, analyze, and assay all beds or deposits of ores, coals, alloys, marls, and such other mineral substances as may be deemed useful or valuable, together with such other duties as may be necessary to make a full and complete geological and mineralogical survey of the State; and to make a report to the legislature, which shall meet next after his election or appointment, of the progress of such survey, accompanied with such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same.

SEC. 3. *Be it further enacted*, That this act shall take effect from its passage, and the geologist and mineralogist first to be elected under this act shall be elected by the present general assembly.

SEC. 4. *Be it further enacted*, That the said geologist and mineralogist shall devote his time exclusively to the duties of his profession, dividing his time as equally as practicable in the different grand divisions of the State, for which he shall receive an annual salary of $1,500, payable quarterly, out of any money in the treasury not otherwise appropriated.

SEC. 5. *Be it further enacted*, That the office of assayer for the State is hereby created; that the said assayer shall be appointed by the governor for the term of two years, and should the said assayer die, resign, or remove from the State during the time for which he was appointed, the governor shall appoint a successor for the unexpired term.

SEC. 6. *Be it further enacted*, That said assayer shall receive no salary from the State, but shall be entitled to the perquisites of the office, by charging and receiving for each assay a fee not exceeding $5, to be paid by the person for whom the assay is made.

SEC. 7. *Be it further enacted*, That said State assayer shall, upon his appointment, take an oath of office to make a faithful and honest assay or analysis of all ores or minerals, and before he shall be entitled to the fees or perquisites allowed in this act; which oath may be taken and subscribed before any judge of a court of record or acting justice of the peace of the State of Tennessee, and filed with the secretary of state.

This act remained in force until 1860, when the survey was abolished, to be revived again under the same directorship in 1871. The following are transcripts of the acts bearing upon these changes:

Be it enacted by the General Assembly of the State of Tennessee, That the office of geologist and mineralogist of the State be, and the same is hereby abolished, and sections 253 and 259 of the code are repealed.

Passed February 1, 1860.

Resolved by the General Assembly of the State of Tennessee, That 2,500 copies of the final geological report of the State geologist, with the necessary illustrations and maps, be printed, under the supervision of the State geologist and librarian, in a style similar and equal to the Kentucky geological report now in the State library.

Resolved, That 500 copies of it be placed in the hands of the State librarian, to be disposed of as follows: One hundred to be used for the purposes of exchanging with other States; 50 copies to the present State geologist, Professor Safford; 50 copies to be deposited in the State library; and the remainder of the 500 copies to be sold by the State librarian, or his agents, at not less than $1 per copy.

Resolved further, That of the number of copies ordered above, 500 shall be for the use of the senate and 1,500 for the use of the house of representatives; and the secretary of state is hereby instructed to distribute said copies as soon as published, sending to each member of the general assembly 20 copies; and the expense of carrying out this resolution shall be paid out of any money in the treasury not otherwise appropriated.

Adopted February 7, 1860.

Act of 1871:

SECTION 1. *Be it enacted by the General Assembly of the State of Tennessee*, That the office of geologist and mineralogist of the State is hereby created; said office shall be filled by appointment of the governor, with the concurrence of the senate, the term of office to be two years, and until a successor is appointed.

SEC. 2. *Be it further enacted*, That it shall be the duty of said geologist and mineralogist to prosecute a topographical, geological, and mineralogical survey of the State, with a view to the full development of all ores, coals, clays, marls, and such other mineral substances as may be deemed useful or valuable, together with such other duties as may be necessary to make a full and complete geological survey of the State, and to this end that he apply for the benefits of the United States Coast Survey in the triangulation of the area of the State, and that he make a report to the first session of each legislature, showing the progress of such surveys, accompanied with such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same, which reports shall not be published unless expressly ordered by the legislature.

SEC. 3. *Be it further enacted*, That said geologist and mineralogist shall devote at least three months of each and every year exclusively to the duties of said office until the State shall be in a condition to employ a greater part of his time, and for the three months of each and every year thus devoted to the duties of said office the incumbent shall receive from the treasurer of the State the sum of $300.

SEC. 4. *Be it further enacted*, That this act take effect from and after its passage, the public welfare requiring it.

Administration.—Under the act of 1854 Dr. James M. Safford was elected State geologist for a term of two years, and was reelected in 1856 and again in 1858. He entered upon his work at once, having made arrangements with the authorities of the university for the temporary filling of his chair. In the prosecution of the work the lack of assistants and the limited means supplied embarrassed him greatly. Furthermore, the geographical and topographical maps of the State, as above noted, were very defective. For many sections he was compelled to construct his own maps.

In 1856 Safford presented a preliminary report, which was published under the title of A Geological Reconnoissance of the State of Tennessee. This was a small volume of 164 pages, octavo, which was accompanied by a geological map of the State.

In 1858 he presented a short statement to the legislature as to the future of the survey, but made no regular report.

In 1860, under authority of a resolution of the State legislature, Safford undertook as full a report on the geology of the State as was practicable, provisions being made for maps and illustrations. Unfortunately, the breaking out of the Civil War put a stop to this work. A number of plates of fossils and other illustrations had been printed, but these, with other materials, were scattered and lost. In the meantime the office of State geologist was abolished and all work suspended.

By a resolution of March, 1868, Safford was authorized to proceed, under the order of February, 1860, to make out a report and present it to the State printer, for which labor he was to receive $1,500. The copies of the report when printed were to be disposed of and distributed according to the requirements of the resolution of 1860 ordering its publication. Twenty-five hundred copies were thus to be printed, with the necessary illustrations and maps, in a style similar and equal to those of the Kentucky reports. Of these, 500 copies were to be placed in the hands of the State librarian, to be disposed of as follows: One hundred to be used for the purpose of exchange with other States, 50 to be presented to the State geologist, 50 to be deposited in the library, and the remainder to be sold at not less than $1 a copy. Five hundred copies were to be distributed among the members of the senate and 1,500 among the members of the house of representatives.

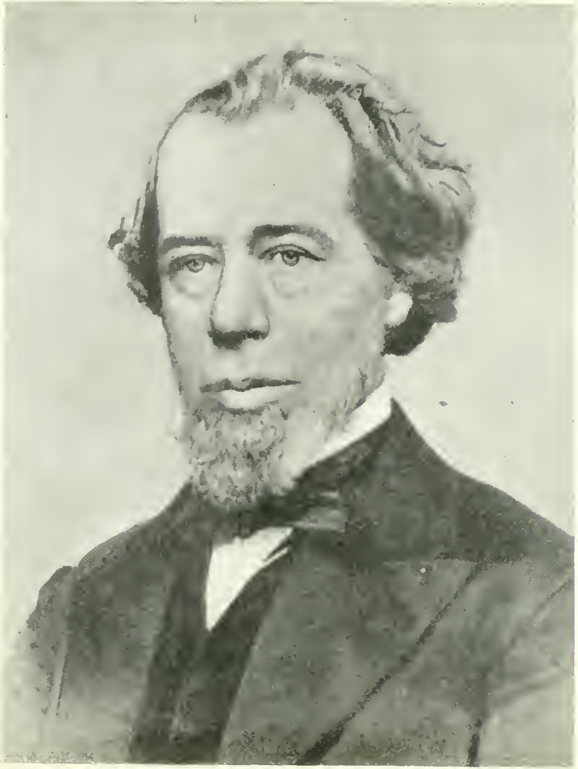
This report was finally printed under the title of Geology of Tennessee, and was ready for distribution in 1869. It was in form of an octavo volume of 550 pages, containing a geological map of the State, seven plates of fossils, and a number of sections and other illustrations.

Under the act of 1871 Professor Safford was again appointed State geologist and mineralogist, and remained in office down to 1900, being reappointed by each succeeding governor. During this period his summer vacations were employed in the work of the survey, though during a part of the time he was much crippled by failure on the part of the legislature to provide for his salary, and but for his connection with Vanderbilt University at Nashville, he could not have afforded to retain the office.

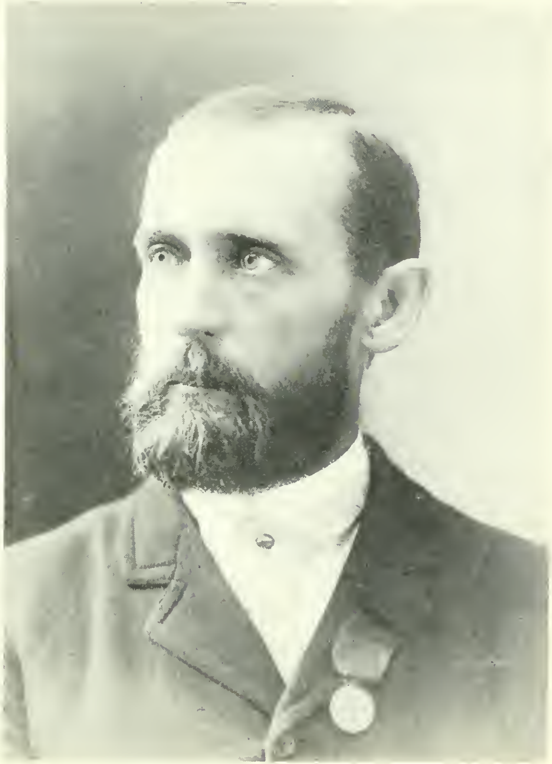
During the interval between 1871 and 1900 reports of progress from time to time were prepared, but were not published, the idea being to accumulate and retain materials for a large report or for a second revised and enlarged edition of his Geology of Tennessee. In the meantime articles and chapters including more or less of the results obtained were contributed to the publications of the Tennessee agricultural bureau and the reports of the commissioner of agriculture, statistics, and mines, and the *American Journal of Science*.

After the enactment of the law of 1871 application was made to the United States Coast and Geodetic Survey for a beginning of geodetic work in Tennessee, to which they were entitled. This work was ordered, and Prof. A. H. Buchanan, of Lebanon, Tennessee, was commissioned to carry it on. As State geologist, Professor Safford directed that he should, first of all, proceed to connect Nashville and Knoxville by triangulation. This was successfully accomplished, and subsequently he was directed to select his points west of Nashville and connect that city with the Mississippi River, the purpose being to secure at least a surveyed belt lengthwise through the State which might, until the whole of the State could be triangulated, serve as a basis for the utilization of the railroad, county, and other maps, and for the location of points. This work was begun, when Professor Buchanan was ordered back to Washington on account of the failure of Congress to appropriate the necessary means.

Expense.—The expense of the survey for the six years ending with 1859 would seem to have been covered, exclusive of publications, by the appropriations—$9,000. The $1,500 appropriated in March, 1868, for the compilation of the volume, Geology of Tennessee, gives a total of $10,500. Under the law of 1871 the geologist was to receive $300 a year, but though reappointed to the office by each



BENJAMIN FRANKLIN SHUMARD, 1858-61



EDWIN THEODORE DUMBLE, 1887-96

STATE GEOLOGISTS OF TEXAS.

succeeding governor, the legislature, "during a part of the time," neglected to provide for his salary. Hence, no figures that may be considered exact can be given.

TEXAS.

FIRST SURVEY UNDER B. F. SHUMARD AND F. MOORE, JR., 1858–1861.

The first systematic attempt at a geological survey of Texas under State authority was made under an act approved February 10, 1858. The immediate motive, as given in this act, was to have made as speedily as possible a thorough and complete geological survey of the State so as to determine accurately the quality and characteristics of the soil and its adaptation to agricultural purposes, its mineral resources, its water power, and generally everything relating to the geological and agricultural character of the State. The survey was entirely independent of any other institution and was to be sustained by annual appropriations. The following is the text of the law:

An act to provide for a geological and agricultural survey of the State.

SECTION 1. *Be it enacted by the Legislature of the State of Texas*, That the governor is hereby authorized to appoint, as soon as possible, some suitable and competent person as State geologist, who shall hold his office for two years, and until his successor shall be appointed and qualified, unless removed by the governor for neglect to perform the duties of his office, or for malfeasance in office, and who shall perform the duties herein prescribed, and during the period of his service shall hold no other office. And before entering upon the discharge of the duties of his office he shall enter into bond, with security, to be approved by the governor, in the sum of $20,000, conditioned for the faithful discharge of the duties of his office.

SEC. 2. That said State geologist shall, as speedily as possible, make a thorough and complete geological survey of the State, so as to determine accurately the quality and characteristics of the soil, and its adaptation to agricultural purposes; the species of produce to which the soil, in different sections, is best adapted; its mineral resources, their location, and the best means for their development; its water powers, their localities and capacities; and generally everything relating to the geological and agricultural character of the State. And for the purpose of carrying out the provisions of this act said geologist shall have power to appoint assistants, with the approbation of the governor: *Provided*, That not more than two assistants shall be appointed.

SEC. 3. That said State geologist shall keep his office at the city of Austin, but shall not be required to remain in said office except as his duties allow; and shall keep in said office such specimens as he shall deem necessary to convey to such office. He shall also forward to the governor, from time to time, during the progress of the survey, specimens of rocks, ores, coals, soils, fossils, and other mineral substances as may be necessary and proper to form a complete cabinet of specimens of the geology and mineralogy of the State; and the governor shall cause the same to be deposited, in proper order, in some convenient room at the capitol of the State, there to be preserved for public inspection. And said geologist shall make a report to the legislature, at its regular sessions, of his surveys, explorations, and examinations into the mineral and other natural resources of the State, its climate and agricultural adaptability, accompanied by illustrative maps, charts, and drawings, with reference to the same, which report shall be the exclusive property of the State: *Provided, however*, That the said geologist shall not be prohibited from publishing any such facts, maps, charts, and drawings, which it is made his duty to report; and that in making any survey upon the frontier the governor or said State geologist is authorized to request the cooperation of any scientific corps of the United States Army or Navy and an escort of United States troops.

Sec. 4. That the said State geologist, for the performance of said service, shall receive an annual salary of $3,000, to be paid to him quarterly, after he enters upon the duties of his office: and that the sum of $20,000 be, and the same is hereby, appropriated, out of any money in the treasury not otherwise appropriated, to be expended under the direction of the governor, for the purposes of carrying into effect this act, by employing assistants and in defraying the incidental expenses of his office; and upon presentation by the State geologist of the proper vouchers, approved by the governor, the comptroller is hereby authorized to draw his warrant on the treasury for the cost of any chemical apparatus or other outfit deemed necessary by the governor, as well as all other expenses of said survey: *Provided*, The amount expended shall not exceed the amount herein specified and appropriated: *And provided further*, That the salary of each assistant State geologist shall not exceed $1,500 per annum for the time he may be engaged.

Sec. 5. That said State geologist and his assistants, before entering upon the duties of their respective offices, shall make oath, before some competent officer, that they will not purchase any lands in this State, with a view to speculation, during the time they hold their said offices, and that they will not conceal or suppress any information relative to any valuable discovery which they may make, pertaining to the objects of said survey, either from the State or from individuals upon whose lands said discovery may be made, and will so conduct the survey as to give as much publicity as possible to the important results of said survey.

Sec. 6. That the chief geologist and his assistants, upon their removal or resignation, or at the expiration of his office, shall turn over to his or their successors or to the governor all the minerals, shells, maps, plats, and diagrams which they may collect or make during their term of office, and shall communicate all important geological information to their successors acquired during such geological survey.

Sec. 7. That this act shall take effect from its passage.

Approved February 10, 1858.

Administration.—Under this act, B. F. Shumard, of St. Louis, Missouri, was appointed by Gov. H. R. Runnels, on August 28, 1858, State geologist. Assistants were appointed as follows: Assistant geologist, Dr. George G. Shumard;[1] chemist and assistant, Prof.

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[1] According to Hill, Bulletin 45, U. S. Geological Survey, p. 30, there is a tradition that Governor Runnels intended to appoint Dr. G. G. Shumard to the office of State geologist, but by a clerical error the name of his brother, Dr. B. F. Shumard, was inserted in the original commission. This is presumably a mistake, since, in a letter dated May 25, 1858, which is among the archives of the Smithsonian Institution, B. F. Shumard, writing to F. B. Meek, says: "I have been urged by some of my scientific friends to apply for the appointment of chief geologist of Texas and have determined to do so." Subsequent letters dated at Austin make no mention of any such probable error as that indicated in Mr. Hill's note.

W. P. Riddell; topographer, A. R. Roessler; meteorologists, Prof. Caleb G. Forshey, at Rutersville. and Swante Palm, at Austin. These, according to section 2 of the law, were appointed by the geologist, with the approbation of the governor.

Salaries.—Salaries, as provided by section 4 of the law, were: For the State geologist, $3,000; assistant geologist, $1,500. Other salaries not given.

Methods.—Realizing that the climatological and meteorological conditions existing in Texas were of primary importance, one of the first acts of Shumard was to purchase a set of chemical and physical apparatus for the equipment of analytical laboratories and of meteorological stations at the two points mentioned above.

The geological corps proper was divided into field parties, and in January, 1859, entered upon their duties. One, under George G. Shumard, constructed a section of the country between Austin and the Red River, in Grayson County. Shumard also made surveys of Grayson, Fannin, and Cass counties, and partial surveys of Bowie, Red River, and Lamar counties. In addition, he made explorations of the Red River from Coke County to the Louisiana boundary. Professor Riddell was engaged in making surveys of the counties of Caldwell, Guadaloupe, McLennan, and Bosque. B. F. Shumard, himself, made detailed surveys of Burnet and Rusk counties and partial surveys of Travis, Bastrop, Washington, Fayette, and Young counties. His methods, as given in his first annual report, were as follows:

> In making these preliminary surveys careful sections of the strata have been made at all points of outcrop within reasonable distances of the route traveled, and the thickness, stratigraphical order, dip, and mineral and fossil characters of the various beds have been determined with as much precision as possible. * * * In some counties sections of the strata have been measured at more than 150 localities. * * * We made frequent barometrical observations to ascertain the elevation of the country above tidewater, and much attention has been directed to obtaining a correct knowledge of the topographical features.
>
> We have also determined, with as much accuracy as possible, the amount and quality of timber in each county, proportion of timber and prairie, elevation of hills, depth and width of valleys, and the amount of available water power furnished by the streams.
>
> A large share of attention has also been devoted to the agricultural capabilities of these counties. The different varieties of soils and subsoils have been carefully examined, numerous specimens have been collected for future study and analysis, and we have spared no pains to ascertain the most advantageous methods of cultivating and improving them.
>
> Particular search has been made for minerals of economical importance and all mines, whether of prospective or known value, have been examined with special care and the probable amount, richness, and quality of the ores determined. Samples of ores and their accompanying minerals, coals, limestones, marbles, clays, mineral waters, etc., have been collected, and are now deposited

in the laboratory at Austin for chemical analysis and final preservation in the State cabinet.

After a brief winter's work in Austin the survey resumed the field in 1860. Records of this year's work are very meager, for reasons noted later. The personnel of the survey remained the same, with the addition of S. B. Buckley, who was employed by Shumard as a collector of plants.

Museum.—Section 3 of the law required the geologist to forward to the governor, from time to time during the progress of the survey, specimens of rocks, ores, coals, soils, and fossils and other mineral substances, such as might be necessary and proper to form a complete cabinet of specimens of the geology and mineralogy of the State, the same to be deposited in some convenient room at the State capitol to be preserved for public inspection.

Change of director.—Owing to reasons which have never been made fully public, but which, to judge from correspondence and articles in the newspapers of that date, were largely of a political nature, Doctor Shumard was removed from office in 1860, after an administration of some 26 months, to be succeeded in November of the same year by Francis Moore, jr., the last named having the reputation of an honorable and cultured gentleman, of much executive ability, but not a geologist. For many years he had been the editor of the Houston *Daily Telegraph*, the then leading newspaper of the State. Under Moore, S. B. Buckley was appointed first assistant State geologist, Riddell being retained as assistant geologist and chemist, and Roessler as draftsman.

Suspension of survey.—During December of 1860 Messrs. Moore and Buckley made a short reconnoissance through the southern counties of the State, and in March a tour was begun through western Texas. During this latter trip the survey was suspended by the passage of the following resolution:

> *Be it resolved,* (1) That the geological survey be suspended, with the exception of the State geologist and chemist, who shall continue in the survey only so long as it may be necessary to make out the report hereinafter provided for.
>
> (2) That B. F. Shumard, the State geologist, be requested to make a report of his survey so far as the survey has been completed, and for that purpose shall have control over the cabinet and rooms and his notes and the services of the chemist, and he shall receive a like salary heretofore paid the State geologist until the work be completed: *Provided,* Said report shall be made by the 1st of July next; which compensation shall be paid out of the appropriations heretofore made for the support of the geological bureau.
>
> (3) That Dr. Francis Moore, present State geologist, be requested to make out a report of the work executed up to the present time.
>
> Approved April 8, 1861.

In accordance with this resolution. Doctor Shumard was reinstated. with instructions to prepare his final report. What was done toward complying with these instructions can not be definitely ascertained. No reports were published, and presumably the agitation incidental to the Civil War prevented further work. Moore himself left for the North in July, 1861. and Shumard returned to St. Louis with the outbreak of the war.

During the war the State capital was occupied by troops and the laboratories and museum of the survey were converted into a manufactory of percussion caps. The collections of the survey, together with maps and other records, were thus lost and destroyed.

It is stated that, at the opening of the war, Buckley also left the South, taking with him the notes of the survey. At the close of the conflict he returned to Austin, assumed charge of the collections, and secured the passage of a joint resolution repealing the act of April 8, 1861, above given, by which the survey had been suspended, and was himself appointed by Governor Throckmorton, in November, 1866, to take charge of the survey, notwithstanding the protests of Shumard, Roessler, and others.

Publications.—The publications of the survey, as may readily be imagined from what has gone before, were few and of comparatively little importance. A report of progress in the form of a pamphlet of 17 pages was issued in 1859, 1,700 copies being printed; and in 1886 there was printed a partial report on the geology of western Texas, compiled by Gen. H. P. Bee from unpublished manuscript left by the Shumard brothers.[1] Buckley also issued a preliminary report on the geology and agriculture of Texas, in 1866.

Expenses.—The writer has not been able to ascertain the exact cost of the Texas survey under the leadership of Moore and Buckley. Mr. R. T. Hill estimates[2] that the cost under Moore's administration could not have exceeded $4,000, and gives a like figure for the one year of Buckley's administration. The total expense of the survey to November 1, 1859, under the administration of Shumard is given as follows:

Salaries of State geologist and assistants	$5,187.50
Services of draftsman	560.00
Hire of subassistants, teamster, and cooks	1,448.21
Expenses of going to New York for instruments, etc	332.62
Instruments, chemicals, and chemical apparatus	1,030.75
Fitting up geological rooms and laboratory	532.72
Loomis and Christian's account for building stable	480.33

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[1] The papers published by General Bee were, as I am informed by Prof. E. F. Dumble, the record of Doctor Shumard's trip for the United States Government in the forties and not part of his State survey work, the two articles in the appendix of this publication being all that can be credited to the survey.

[2] Bulletin 45, U. S. Geological Survey, 1887.

Horses and mules	1,479.25
Wagons, harness, and saddlery	1,091.95
Outfit, camp expenses, provisions, forage, and blacksmithing	2,488.04
Traveling expenses	236.60
Transportation of specimens, etc	121.32
Postage account	15.48
Stationery	63.38
Exchange	4.85
	$15,073.00

SECOND SURVEY UNDER J. W. GLENN AND S. B. BUCKLEY, 1873–1875.

With the close of the Civil War and the gradual subsidence of the political excitement incident to the reconstruction period, the expediency of reorganizing the survey was again broached, and the following law was passed and approved on August 13, 1870:

An act providing for a geological survey of the State of Texas.

SECTION 1. *Be it enacted by the Legislature of the State of Texas*, That the governor is hereby authorized and directed to appoint, by and with the advice and consent of the Senate, some suitable and competent person as State geologist, who shall hold his office until the completion of the geological survey of the State by this act authorized, or until his successor is appointed and qualified in case of his removal as hereinafter specified, and who shall perform the duties herein prescribed, and during his occupancy of said office shall hold no other office; and before entering upon his duties as State geologist, shall enter into bond, with security to be approved by the governor, in the sum of $5,000, for the faithful performance of the duties of said office.

SEC. 2. That said State geologist shall, as soon as possible after his appointment and qualification, appoint two principal assistants, one of whom shall be an expert, practical, and scientific chemist and mineralogist, and the other a competent geologist, and shall have full authority to appoint such subassistants as may, from time to time, become necessary.

SEC. 3. That said State geologist shall, with the aid of assistants, make, as rapid as may be consistent with accuracy, a thorough geological, mineralogical, and agricultural survey of the State, embracing a scientific and descriptive survey of the rocks, minerals, mineral waters, and fossils of the same, full and complete assays of the ores and minerals, and analysis of the soils and subsoils, with a classification of the same, stating their adaptation to particular crops, and the best methods of preserving and increasing their fertility. They shall also determine the relative ages, order of succession, thickness, dip, strike, and composition of the various building stones, ores, minerals, fossils, fertilizers, and mineral waters, with specimens of the useful native and introduced plants, and all other substances and objects that may be necessary to illustrate the economic and scientific geology, and render the collection a complete museum of practical geology.

SEC. 4. That the governor shall procure safe and suitable rooms, at the capital of the State, for the permanent deposit and arrangement of the collections above mentioned; that said collections shall be arranged and classified in the same by the said State geologist and his assistants, and that this museum shall be the office and headquarters of the survey, and always kept open and freely accessible at seasonable hours to the public, excepting when the members of the geological corps are all absent attending to field duties.

Sec. 5. That the duplicate specimens collected by the survey shall be classified and labeled, when called for, to be distributed to each of the colleges of the State that have been duly authorized to grant diplomas: *Provided*, That each distribution shall only be made after due application of said colleges has been made to the governor.

Sec. 6. That the said State geologist shall present to the governor, at each regular session of the legislature, a report of progress made up to that time, including an account of the more important results accomplished, and that said preliminary reports, if desirable or necessary to their proper understanding, shall be accompanied with maps and other illustrations, and that these, as well as all other reports of said survey that may be made and presented by said State geologist and his assistants, shall be the exclusive property of the State: *Provided*, That said State geologist shall not be prohibited from publishing any such facts, with maps and illustrations, that it may be his duty to present.

Sec. 7. That the salary of said State geologist shall be $3,000 per annum, and that of the principal assistants each $1,800 per annum, together with all traveling and incidental expenses of the said State geologist and his assistants while engaged in the field explorations, to be paid quarterly after they enter upon the duties of their office. All money hereafter appropriated to carry into effect this act shall be expended in the payment of the salaries of the State geologist and principal assistants, and of such subassistants and other aid as it may be necessary to employ, in the purchase of the necessary chemical apparatus, chemicals, and instruments, the transportation of specimens, and the payment of incidental expenses; and upon the presentation by said State geologist of proper vouchers, approved by the governor, the comptroller is hereby authorized to draw his warrant upon the treasury for all bills for sums due or expended as above specified: *Provided*, That the whole amount expended shall not, during any one year, exceed the sum of $20,000.

Sec. 8. That the said State geologist and his assistants, before entering upon the duties of office, shall make oath before some competent officer that they will not purchase any lands or mining interest in the State, with the view of speculation, during the time they hold office, and that they shall not conceal or suppress any information relative to any discovery which they may make pertaining to the objects of the survey, either from the State or from individuals upon whose lands said discovery may be made, and that they will so conduct the survey as to give as much publicity as possible to the important results of the same.

Sec. 9. That on the completion of said survey, or at proper intervals during its progress, as facts may accumulate, said State geologist shall prepare and present to the governor more complete reports, to be considered final as far as they go if presented during the progress of the survey, or final and complete if presented after the whole State shall have been surveyed, which reports shall embody the results of the entire survey, or of that portion of it completed, and shall be accompanied by all such maps, sections, diagrams, and other drawins as may be necessary for a full and complete understanding of the same. And the secretary of state is hereby directed to secure a copyright in the name of the State for all reports presented by the State geologist and published at the expense and by the authority of the State.

Sec. 10. That whenever any such reports are published, the governor may cause them to be sold to the citizens of the State at a price not exceeding the cost of the paper, printing, and binding, and to others on such terms as may be advantageous to the interests of the State; and all moneys that may be received from the sale of said reports shall be placed in the common school fund of the State.

SEC. 11. That said State geologist shall be allowed 50 copies of all reports of said geological survey for distribution to scientific men in this country and in Europe; and that 20 copies of the same shall be in like manner allowed to each of the principal assistants in said survey, in accordance with the usual custom in such surveys.

SEC. 12. That the State geologist shall superintend the publication of his reports provided for in this act, and shall present to the legislature an estimate of the cost of the publication of the same, at the time such reports shall be presented.

SEC. 13. That in case of the death or resignation of said State geologist before the completion of said survey the governor may appoint his successor; and the governor shall have power to remove said State geologist from office for neglect of duty, incompetence, dishonesty, or any kind of malfeasance in office, should he be found guilty of such charges brought against him: *Provided*, due notice has been given to him that such charges have been made, and he shall be allowed full opportunity to confront his accuser and make his defense; and in case of such removal of the State geologist, he shall deliver over to the governor, or to his successor in office, all specimens, instruments, apparatus, maps, sections, diagrams, and other property belonging to the State and relating to the survey.

SEC. 14. That all former laws of the State relating to a State geographical survey are hereby repealed, and that this act take effect and be in force from and after its passage.

Approved August 13, 1870.

Administration.—The general plan of the survey was similar to that of the first attempt, as will be noted. Under the act, early in 1873, Gov. E. J. Davis appointed John W. Glenn State geologist. Charles E. Hall was made first assistant. The salary of the principal geologist was placed at $3,000, and the principal assistants at $1,800 each, the traveling and incidental expenses to be paid by the State. Active work was begun in November in Burnet, Llano, and San Saba counties. Glenn resigned on March 6, 1874, and was succeeded by S. B. Buckley.

No report was published under Glenn's administration. The following from R. T. Hill's report, already quoted, is given as outlining his methods and what he had hoped to accomplish:

> My first work was to establish a base line which would include outcroppings of the known formations. As established, this line began in Blanco County, in the Cretaceous, thence northward until it encountered the Cretaceous, again overlying the Carboniferous in the north part of the State. Between these two ends of the base line, beginning at the south end, it passed through the following formations in the order as stated, viz: Cretaceous, Carboniferous, Upper Silurian, Azoic, Lower Silurian, Upper Silurian, Carboniferous, Cretaceous.
>
> The result was one of the most interesting I ever accomplished. Every square mile of the territory surveyed was carefully platted on the map and defined in

the field, and each one numbered and worked over with great care, and the collections taken from each bore its number and from what part each came. Probably the most valuable part of my work, from an economic stand, if the report of it had only been promulgated in print, was my report on the wild sumach of Texas (*R. copallina*), from detailed analyses extending through the entire growth and determining the period of greatest economic value in tannic acid.[1]

Doctor Buckley received his appointment from Gov. Richard Coke in March, 1874. Under his administration, Richard Burleson was made assistant geologist: Charles E. Hall, subordinate assistant: James E. Horne, bookkeeper and commissary; and Friench Simpson and Jack Coke, volunteer assistants. Field work was begun on May 11. The entire work of the survey was, however, in the nature of reconnoissance, and no stratigraphic or topographic work was done, nor were any barometric or other observations made.

Expenses.—The expenses, as given in Buckley's report for a period from May 1, 1874, to November 1 of the same year, were as follows:

Outfit at Austin.

One pair mules, of Mr. Hart	$366.00
One ambulance	137.50
One pair mules and wagon	330.00
One pair of mules and hack bought by Professor Burleson at Waco	675.00
	$1,508.50

Expenses in the field.

May	$73.00
June	159.20
July	264.85
August	135.45
September	115.20
October	122.80
	[2] $870.50

Wages paid.

James Horne, $50 per month	$300
Shands, $25 per month	150
Carrington, $25 per month	150
Cook, $25 per month	150
	$750

R. T. Hill, in the publication above referred to, gives the following statement, as obtained from Mr. F. Simpson:

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[1] This report was published in part, at least, by the succeeding survey in Bulletin No. 1, Report and Analyses of Texas Sumach (*Rhus copallina*) by George H. Kalteyer, Austin, 1892.

[2] The printed report gives this total as $871.15.

Total amount of appropriation for 1874		$7, 250
Salary of geologist	$3, 000	
Office and chemical supplies	300	
Wood	50	
Books and instruments	200	
Traveling expenses	2, 700	
Total		6, 250
Returned to the treasury		$1, 000

In 1875 the expenses are given by the authority mentioned, as follows:

Salary of the geologist	$3, 000
Office and chemicals	500
Traveling expenses	2, 000
Postage	200
Fuel	50
Total	$5, 750

At the end of this fiscal year Gov. Richard Coke became convinced that the geological survey, as conducted, was of no value to the State and vetoed the bill for the annual appropriation. Thus the second attempt at a survey was brought to an end.

Publications.—Two reports, of 142 and 96 pages, were issued by Buckley under dates of 1874 and 1876, respectively. Concerning their value, Mr. Dumble writes:

> I want to call especial attention to the fact that while Buckley's publications were crude, a careful reading shows that some definite results of value were secured, among these the general lines of Tertiary-Cretaceous and Cretaceous-Carboniferous boundaries and the presence of true Miocene, the occurrence and source of the artesian water of the Cretaceous area, and the existence and location of some valuable minerals.

THIRD SURVEY UNDER E. T. DUMBLE, 1888–1892.[1]

In 1888 still a third attempt was made for a geological survey under State auspices, and the following is the text of the law under which the work was to be carried out:

An act to authorize the commissioner of agriculture, insurance, statistics, and history to have a geological and mineralogical survey made of the State of Texas, and to make an appropriation therefor.

SECTION 1. *Be it enacted by the Legislature of the State of Texas,* That it shall be the duty of the commissioner of agriculture, insurance, statistics, and history to have a geological and mineralogical survey made of the State of Texas, and for that purpose he shall employ such a number of competent persons skilled in the science of geology and mineralogy as shall be necessary to properly and expeditiously execute said work. The persons so employed shall be under the supervision and control of the said commissioner, and shall receive such compensation as the commissioner may direct, not to exceed $2,000 per year. The commissioner shall provide all necessary chemical apparatus, books, maps, and stationery to carry out the provision of this act, and may employ such additional clerks as shall be requisite to a proper execution of this act, which clerks shall receive such compensation as he may deen proper, not to exceed $900 each per year.

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[1] Compiled mainly from manuscript furnished by E. T. Dumble.

Sec. 2. The commissioner shall cause to be made assays, analyses, or other scientific examination of all beds or deposits of ores, coals, clays, marls, and other mineral substances situated in this State as shall be requisite to a correct knowledge of the extent and value thereof. He shall also in all proper cases upon application require like examinations, assays, or analyses to be made of deposits, mines, and lands situated in this State, and shall furnish proper certificates of the result of such examination, assay, or analyses. He shall also upon request of any person require assays or analyses to be made of any specimen of soil or mineral deposits in this State, and shall also furnish to the party requesting it a certificate thereof: *Provided*, That in all cases when assays or analyses are made upon request of any person the party making the request shall be required by the commissioner to make affidavit that the specimen offered was found upon the land of the party making the request, or that said request is made at the instance or with the full knowledge and consent of the owner of the land upon which said specimen was found.

Sec. 3. The commissioner shall preserve a record of this department of his office, and the information therein collected and preserved shall be reported to the governor as in case of other matters relating to his office. He shall also report to the governor before each session of succeeding legislatures, for information of the governor and such legislatures, all money expended under this act, and how and for what purpose such money was expended. He shall also report the amounts of money received from persons, corporations, or syndicates for services rendered, specifying the amount so received. He shall also preserve specimens of minerals, coals, stones, and other natural substances useful in agricultural, manufacturing, or the mechanical arts, and shall from time to time as far as practicable add specimens of organic remains and other objects of natural history peculiar to this State.

Sec. 4. The commissioner shall prescribe a schedule of reasonable fees to be charged and collected from all persons having scientific examinations, assays, or chemical analyses made, and for certificates furnished under this act, which fees shall when collected be paid into the State treasury to the credit of the general revenue fund.

Sec. 5. It shall be unlawful for the commissioner of agriculture, insurance, statistics, and history, or any person employed by him or connected with his office, to purchase all or any part of any mine or mineral lands, or be in any manner interested in such purchase, during the term of his office or employment. Any person violating the provisions of this section shall be punished by fine not less than $1,000, and shall be removed from his office or employment, as the case may be.

Sec. 6. That the sum of $15,000, or so much thereof as may be necessary, be, and the same is hereby, appropriated, out of any moneys in the State treasury not otherwise appropriated, for the purpose of carrying out the provisions of this act: *Provided*, That no expense in excess of the amount hereby appropriated shall be incurred under the provisions of this act.

SEC. 7. The great necessity for gathering and collecting useful and valuable information concerning the mineral and other natural resources of the State, and the present lack of means to ascertain the same, creates an imperative public necessity, and an emergency exists requiring that the constitutional rule which requires bills to be read on three several days in each house be suspended, and said rule is so suspended, and it is enacted that this act take effect and be in force from and after its passage.

NOTE.—The foregoing act originated in the house, and passed the same by a vote of 45 yeas, 37 nays; and passed the senate by a vote of 24 yeas, 4 nays.

Approved May 12, 1888.

Immediate control of the survey, as noted, was in the hands of State commissioner of agriculture, insurance, statistics, and history, and it had no connection with any other institution. It was to be supported by annual appropriations.

Administration.—Under this act, the commissioner, L. L. Foster, on September 21, 1888, appointed E. T. Dumble State geologist, giving him full control of the work of the survey, reserving only a supervision of the finances. Mr. Dumble appointed the following assistants: Geologists, W. H. von Streeruwitz, W. F. Cummins, Dr. R. A. F. Penrose, jr.; chemist, J. H. Herndon.

The salary of the State geologist was placed at $2,000 and that of geologists at $1,800 each, traveling and incidental expenses to be paid by the State. The only change in these salaries was during the years 1891 and 1892, when they were made by law $2,500 and $2,300, respectively, being again lowered to the original amounts in 1893.

Arrangements were made by which the chemical laboratory of the University of Texas was utilized temporarily for the chemical work of the survey, and circular No. 1 was issued October 1 to apprise those wishing analyses of the conditions. The charges for analyzing and assaying minerals and ores were only sufficient to cover cost of materials and not of services. The fees received for this work, however, were to be paid into the State treasury to the credit of the general reserve fund. The only point which needs to be considered was the fact that such analyses were to be made, as provided in section 2 of the law, only on presentation of an "affidavit that the specimen offered was found upon the land of the party making the request, or that said request was made at the instance or with the full knowledge and consent of the owner of the land upon which specimen was found."

The immediate motive of the survey, as outlined in circular No. 2, issued October 11, was as follows:

1. A search for ores, minerals, oils, coals, clays, and other minerals possessing a commercial value, and the determination of the question, whenever possible, whether they exist in sufficient quantities

and under suitable conditions and surroundings to make it reasonably certain that it will be profitable to work them.

2. An investigation of the geological formation and the topography of the country with a view to determining the probability of obtaining artesian water and the feasibility of irrigating from such wells as well as from streams, shallow wells, or tanks, where necessary.

3. The determination of the adaptability of soils to certain crops, and how their fertility can be increased by the use of materials nearest at hand.

4. The search for and development of useful articles as yet not fully known.

Preliminary work.—The short time intervening between the preliminary organization of the survey and the meeting of the legislature, for which a report had to be prepared, made it necessary to spend the time in a very rapid reconnoissance in order to get together as much general information as possible regarding the mineral deposits of the State for the information and use of the legislature.

Von Streeruwitz reported for duty on September 29, and was sent out with instructions to make a careful investigation of the mineral and agricultural resources of the trans-Pecos region. Cummins reported on October 2 and took the field with instructions to make a section of the central coal formation, determining the number of coal seams which exist in it, together with their character and thickness. Penrose, owing to previous engagements, did not report for duty until November 12, when he began work by proceeding to Jefferson to investigate the iron, limestone, and asphaltum deposits of east Texas. Work in southern Texas was apportioned to J. Owen, of Eagle Pass; J. L. Tait and G. Jermy, of San Antonio, as temporary assistants.

The results of the three months' work in the form of reports from the geologists and assistants, together with an introduction by the State geologist, were published as the first report of progress, and upon the showing made the legislature made appropriation for the continuance of the work for two years from March 1, 1889.

The work being provided for biennially, the State geologist decided that the first year of each term would be devoted to the broader features of areal and stratigraphic geology with special reference to the occurrence of mineral deposits, while the work of the second year would be principally the study of these deposits and a more detailed investigation of the beds containing them, and thereafter planned the work of each field party accordingly.

The geologists named were continued in the field. Additional chemical work was provided for at the Agricultural and Mechanical

College of Texas and P. S. Tilson appointed chemist. T. B. Comstock was engaged for special work in the Llano region during the summer months and later was appointed geologist. The United States Geological Survey cooperated by detailing Robert T. Hill to carry on the study of the Cretaceous in connection with his work at the university during the latter part of the year.

The importance of accurate topographic work was realized and efforts were made to secure the cooperation of the United States Geological Survey and United States Coast and Geodetic Survey, which were partially successful. This was supplemented by the survey through the work of J. C. Nagle in central Texas and R. Wyschetzki in the trans-Pecos.

Work of first year (1889).—Von Streeruwitz completed his reconnoissance of the trans-Pecos and in May began regular work there, the first year being occupied principally in constructing a topographic map of the western portion of El Paso County.

Cummins made several sections across the northwestern portion of the State from the escarpment of the Llano Estacado to the Cretaceous border on the east, and began the instrumental sections, which were completed later. He had the assistance of Messrs. McCulloch and Drake. R. S. Tarr, appointed in November, was given the study of the southern border of the central coal field.

Penrose spent the early part of the year in detailed examination of Cherokee County with its iron ores and lignites. After this, in order to get the Tertiary sections more complete, he made a boat trip down the Brazos, Colorado, and Rio Grande. Penrose left the survey on July 1 to study the extension of the Tertiary deposits in Arkansas under the geological survey of that State while the iron-ore areas of Texas were being mapped. The Arkansas work proved to be so extensive, however, that he finally resigned from the Texas survey. G. E. Ladd was appointed to trace and map the iron-ore deposits of east Texas, and worked in Wood, Upshur, Van Zandt, Marion, and Anderson counties, and then resigned on account of ill-health. A. G. Taff was appointed to continue this work, but died before completing a single county.

To Comstock was assigned the special work of studying the geology and resources of the Llano district. With his party, which included Messrs. Nagle, Spence, and Huppertz, he covered a large portion of the area during the season and made large collections of the rocks and minerals of the district.

R. T. Hill, in connection with his work at the University of Texas, was given the examination of the Cretaceous. His detail under the United States Geological Survey for this work began in July. He had as assistants Messrs. J. A. Taff, C. C. McCulloch, N. F. Drake, and J. S. Stone. A room was set apart for a museum and was furnished with cases and a start made toward the installation of specimens sent in by the field parties, Mr. J. B. Walker being in charge.

The general results of the work of the first year are summarized by Mr. Dumble in the first annual report, 1889, (pp. xxix–lxxiii), in which a brief statement is made covering the various geological horizons recognized during the field work and the principal mineral resources of each, fuller details being given in the accompanying papers, pages 1 to 410, which comprise:

A Preliminary Report of the Geology of the Gulf Tertiary of Texas, by R. A. F. Penrose, jr.

A Brief Description of the Cretaceous Rocks of Texas and their Economic Value, by Robert T. Hill.

The Southern Border of the Central Coal Field, by W. F. Cummins.

The Permian of Texas and Its Underlying Beds, by W. F. Cummins.

Preliminary Report on the Coal Fields of Colorado River, by Ralph S. Tarr.

Geology of Trans-Pecos Texas — Preliminary Statement, by W. H. von Streeruwitz.

Preliminary Report on the Geology of the Central Mineral Region of Texas, by Theo. B. Comstock.

In addition to the first annual report the survey published during the year:

Bulletin No. 1. A Preliminary Annotated Check List of the Cretaceous Invertebrate Fossils of Texas, by R. T. Hill.

Bulletin No. 2. A Preliminary Report on the Soils and Waters of the Upper Rio Grande and Pecos Valleys in Texas, by H. H. Harrington.

These papers, after recounting as fully as possible the work of earlier investigators, give, as far as the facts at hand seem to warrant, the results of the authors' own geological observations. Taken in connection with the summary by Mr. Dumble, they furnish the first comprehensive description of the geology of Texas and are the basis of the subsequent work of the survey.

Work of second year (1890).—Dr. R. S. Woodward, in connection with his work of establishing the one hundred and fifth meridian, remeasured the Texas base line and the principal triangulation points of Von Streeruwitz's previous year's work, verifying its correctness: and in November Captain Forney, of the United States Coast and Geodetic Survey, reached El Paso for the work of primary triangulation of the Rio Grande border. Von Streeruwitz, in addition to continuing the work of mapping the area, made such examination as the conditions would permit of the mineral deposits of the region. J. A. Taff was attached to Von Streeruwitz's party for the examination of the Cretaceous deposits of the area.

Comstock completed the work begun in the central mineral region, securing an accurate topographic map of the area and mapping the general geology and locating the principal deposits of useful minerals, so far as known. He had as assistants Messrs. J. C. Nagle, C. A. Huppertz, R. A. Thompson, and H. B. Jones. In September Mr. Nagle left the survey to accept an appointment as assistant professor of engineering at the agricultural and mechanical college. Tarr made a reconnoissance of the Guadalupe Mountains, and then resigned to accept work at Cornell University. Cummins took up the detailed study of the coal measures of the central coal field, making careful instrumental sections across them and locating the outcrop of the two workable seams across the territory. R. T. Hill was appointed geologist in charge of the Cretaceous area, and as such studied the geology of the Red River region from Texarkana to Denison, having as assistants Messrs. J. S. Stone, J. A. Taff, L. T. Dashiel, G. H. Ragsdale, and W. T. Davidson. He resigned from the survey on September 30.

The work in east Texas was under the personal supervision of Mr. Dumble. Mr. W. Kennedy mapped the iron ores of Cass, Harrison, and other counties and made reconnoissance of Gregg and Marion. Mr. Herndon mapped the iron ores of Smith County and Mr. Walker those of Rusk, Panola, Shelby, and Nacogdoches.

A part of Penrose's collections of Tertiary fossils were studied by Prof. A. Heilprin; parts of the Cretaceous collections were sent to Dr. F. Roemer at Breslau; and Prof. Alpheus Hyatt determined and described a number of nautiloid forms from Cummins's collections.

The chemical laboratory was moved to the basement of the capitol late in 1889 and Mr. L. E. Magnenat appointed assistant, and on the resignation of Mr. Tilson to accept the position of assistant professor of chemistry at the agricultural and mechanical college, all the chemical work was concentrated at the survey laboratory.

But little progress was made in museum work, but the library was enlarged by purchase as much as the funds would permit.

To supply a demand from the public high schools a number of small collections of minerals were made up and 40 of them were distributed during the year.

Results.—Under the heading Mineral Resources of Texas in the second annual report, 1890, Mr. Dumble gives a summary of the mineral deposits found to exist in the State, and also describes the various artesian water belts found within it. The bulk of this volume, containing 800 pages, is made up of the detailed reports of the various geologists and assistants. The papers are as follows:

Report on the Iron Ore District of East Texas: General statement and reports on Anderson and Houston Counties, E. T. Dumble; Charcoal manufacture in Texas, John Birkinbine; Lignites and their utilization, O. Lerch; Reports on Cass, Marion, Harrison, Gregg, Morris, Upshur, Van Zandt, and Henderson

Counties, W. Kennedy; Smith County, J. S. Herndon; Panola, Shelby, Rusk, Nacogdoches, and Cherokee Counties, J. B. Walker.

Carboniferous cephalopods, A. Hyatt.

Report on the Geology of Northwest Texas, W. F. Cummins, including Young, Montague, Jack, Wise, Parker, Palo Pinto, Stephens, Brown, Eastland, and Coleman Counties.

Report on the Geology and Mineral Resources of Central Mineral Region of Texas, T. B. Comstock.

Report on the Geology and Mineral Resources of Trans-Pecos Texas, W. H. von Streeruwitz.

This volume gives the location and extent of the deposits of limonite ores of east Texas, descriptions of the lignites, greensand marls, clays, petroleum, and other valuable mineral deposits of the same district, map and descriptions of the workable coal beds of the State, and of the varied mineral resources of the Llano district and of a portion of trans-Pecos Texas. Tarr's report on the Guadalupe Mountains was published at Bulletin No. 3. A. C. Gray was put in charge of the general office work and edited the second annual and subsequent reports of the survey.

In his message to the twenty-first legislature, Gov. L. S. Ross thus referred to the work of the survey:

> In this connection is presented the report of Professor Dumble, the State geologist, on the agricultural and economic geology of the State. The public long felt the need of more reliable and practical information relative to the soils of our State and the formations underlying them and their adaptation to crops. Nothing, in my opinion, has contributed more effectively in bringing into notice the resources of our State than the work of Professor Dumble and his assistants, and adequate appropriations should be made to meet the necessary expenses in continuing this work on a more extended scale.

At this time a very determined fight was begun against Mr. Dumble as State geologist by certain members and exmembers of the survey, and charges of incompetency and plagiarism were submitted to Governor Hogg after his inauguration in 1891. They were investigated publicly by Mr. John E. Hollingsworth, commissioner of agriculture, insurance, statistics, and history, and the charges were dismissed.

The legislature of 1891 not only made provision for continuing the survey, but added a special appropriation of $3,000 for an investigation of lignite.

Work of the third year (1891).—In the second report of progress Mr. Dumble gives a condensed statement of the work of the year.

The parties left for the field in May and June. To extend the knowledge of the Gulf Tertiaries three general sections were planned, using levels of the railroad lines as base for obtaining elevations, supplemented by transit and level lines where needed. Mr. Kennedy made the section from Terrell by way of Minneola, Tyler, Jacksonville, Trinity, Corrigan, and Colmesniel to the Gulf at Sabine Pass. Mr. Walker's section was west of the Colorado River from Cameron to Galveston.

Mr. Taff began at Corpus Christi and made his section by way of Laredo, Cotulla, and Carrizo Springs to Uvalde. This done, Mr. Kennedy made a detailed study of Houston County; Mr. Walker worked in Washington County; and Mr. Taff traced some of the Cretaceous partings from Uvalde to Austin, after which he took up the study of the Cretaceous deposits and made a careful section across Lampasas and Williamson counties. Cummins followed and mapped the Cretaceous escarpment west from San Angelo to the Staked Plains; followed the foot of the plains northward to the Fort Worth and Denver Railroad; crossed over into New Mexico and followed the valley of the Pecos River to Pecos City, practically circling the Llano Estacado.

Comstock similarly crossed the Cretaceous southwestwardly from San Angelo, making a close instrumental section through Sleicher, Sutton, Val Verde, Kinney, and Maverick counties to the Rio Grande; thence northward through Uvalde, Edwards, Bandera, Kerr, and Gillespie, connecting with his work of the previous year.

Von Streeruwitz returned to trans-Pecos, Texas, and as the United States Geological Survey had undertaken the further topographic work of that region, he took up work farther east in the Diabolo and Carrizo Mountains. Mr. Singley was detailed to watch the progress of the deep well at Galveston. Mr. Dumble, with the assistance of Mr. J. Owen, made a section of the Cretaceous along the Rio Grande between Eagle Pass and Del Rio, and then took up the lignite investigation, visiting the various lignite fields of Germany and Austria, as well as numerous Texas localities.

Mr. Herndon was relieved from duty May 6 and Mr. Magnenat appointed to succeed him, with the assistance of G. H. Wooten. Comstock resigned to accept the directorship of the Arizona School of Mines, and did not submit report of his work.

Such paleontologic work as was done was by specialists. Professor Cummins's nautiloid forms were again sent to Prof. A. Hyatt, while the fossil plants collected from the Carboniferous and Permian were sent to I. C. White and the vertebrate fossils to E. D. Cope. The Cretaceous echinoderms were sent to W. B. Clark of Johns Hopkins University.

The collections in the museum were greatly enlarged and better classified, and 20 collections of minerals distributed to high schools.

The detailed results of the work were contained in the reports of the geologists and assistants, appearing in the second report of progress and in the third annual report, 1891. These comprise:

Report of the State geologist, E. T. Dumble.

Report on Houston County and Section from Terrell to Sabine Pass, W. Kennedy.

Llano Estacado or Staked Plains, W. F. Cummins.

Notes on the Geology of the Country West of the Plains, W. F. Cummins.

Stratigraphy of the Triassic Formation in Northwest Texas, N. F. Drake.

Report on Paleontology of the Vertebrata, E. D. Cope.

Shells Collected in a Dry Salt Lake near Eddy, New Mexico, V. Sterki.

Reports on the Cretaceous Area North of the Colorado River, J. A. Taff.

Trans-Pecos Texas, W. H. von Streeruwitz.

In this volume the general geological section of the first year's work is expanded by the additional information secured, especially in the western and northwestern portions of the State.

The results of the lignite investigation by Mr. Dumble were published separately as a Report on the Brown Coal and Lignite of Texas, a volume of 243 pages, giving descriptions of the various methods of utilizing lignites in Germany and Austria, descriptions of all known occurrences of lignite in Texas, with analyses, comparison of the lignites of Europe and Texas, and recommendations as to their utilization.

Work of the fourth year (1892).—In the coastal area a preliminary section was made by Messrs. Dumble, Cragin, Kennedy, Singley, and Ragsdale, through Lee, Washington, and Waller counties, after which Mr. Kennedy took up the detailed examination of Grimes, Brazos, and Robertson counties. Mr. Singley remained at Galveston until the completion of the well at 3,070 feet, securing a large collection of material from it.

Mr. Taff, assisted by Mr. Leverett, extended the work of the previous year northward from Waco to Red River, with especial reference to the artesian water conditions of the area. Messrs. Drake and Thompson made a detailed study of that part of the Carboniferous area lying between the Colorado and the Brazos divides, carefully mapping the coal seams and other beds of value.

E. D. Cope, with Cummins, made a trip along the Llano Estacado for the purpose of collecting vertebrate fossils from the Triassic and Tertiary beds, after which Cummins's work embraced the examination of special localities in the Permian or red beds area, including the copper horizons.

Von Streeruwitz continued his work in west Texas. Dr. A. Osann was appointed mineralogist and petrographer of the survey and began work in December. Messrs. Magnenat and Wooten were in charge of the laboratory until September 1, when they resigned. Dr.

W. H. Melville, of the United States Geological Survey, was then appointed chemist, with Mr. L. E. Dickson as assistant. F. W. Cragin was appointed to study the large collection of Cretaceous fossils, and G. D. Harris to study the Tertiary invertebrates. Professor Hyatt continued his work on the Carboniferous cephalapods and E. D. Cope on the vertebrates. The museum collection was greatly enlarged and improved during the year.

The fourth annual report, 1892, comprising the published results of this work, was submitted for publication as usual, but the printing board decided that only 1,100 copies could be printed and that none could be bound. Permission was obtained, however, to print the report in parts, of which 11 were issued, as follows:

Part 1. Report of State Geologist.

Part 2. Report on Grimes, Brazos, and Robertson Counties, W. Kennedy.

Part 3. Preliminary Report on the Artesian Wells of the Gulf Coastal Slope, J. A. Singley; Preliminary Report on the Organic Remains Obtained from the Deep Well at Galveston, G. D. Harris.

Part 4. Report on the Rocks of Trans-Pecos, Texas, A. Osann; Trans-Pecos, Texas, W. H. von Streeruwitz.

Part 5. Notes on the Geology of Northwest Texas, W. F. Cummins.

Part 6. Report on the Cretaceous Area North of the Colorado River, J. A. Taff, S. Leverett, assistant.

Part 7. Report on the Colorado Coal Field of Texas, N. F. Drake; Report on Soils, Water Supply, and Irrigation of the Colorado Coal Field, R. A. Thompson.

Part 8. A Preliminary Report on the Vertebrate Paleontology of the Llano Estacado, E. D. Cope.

Part 9. Contribution to the Invertebrate Paleontology of the Texas Cretaceous, F. W. Cragin.

Part 10. Contributions to the Natural History of Texas, J. A. Singley.

Part 11. Carboniferous Cephalopods, second paper, Alpheus Hyatt.

There was also published during the year Bulletin No. 1, containing:

Artesian Water on the Llano Estacado, by Dr. George G. Shumard.

Report and Analyses of Texas Sumach (*Rhus copallina*), by George H. Kalteyer.

With the issuance of the fourth annual report, the printed record of the survey ceases. Its history after that time is supplied by Mr. Dumble from copies of manuscript in his possession and others in the State archives.

Work of the fifth year (1893).—The fight against the survey which began at the former legislature was taken up again before the twenty-third and its opponents succeeded in having the amount of the appropriation reduced from $35,000 to $20,000 a year. The total of the general appropriation bill, however, so far exceeded the probable receipts that in order to prevent a deficiency serious to the

State's financial interest. Governor Hogg vetoed a great number of items, among them that of the survey for the second year. In his message he writes the cause thus:

> For the reason that for the year ending February 28, 1894, a like appropriation of $20,000 is made, and that by the time it is exhausted such work will have progressed far in advance of the demands of the times. The State can not engage in the mining business, but must give way to private enterprise and capital. Up to date, through the efficient corps of the scientific gentlemen connected with and in charge of the geological department, she has pointed the way to mines and minerals of great value on public and private lands, and has laid out work enough to engage industry and capital of immense proportions for many years to come. It is deemed advisable now not to destroy but to preserve intact the rich mineral specimens gathered and the valuable surveys made by this department until such time in the future, after the expiration of the current year, as public interest may dictate that the survey shall be renewed and continued.

This reduced appropriation necessitated a rearrangement of the forces, and efforts were directed chiefly toward the completion of the work in hand and filling in the gaps. To bring expenditures within appropriation, nearly all the force was discontinued on September 1, others being continued until their reports were completed.

Mr. Kennedy spent two months without result watching the sinking of a well by the Gladys City Oil Company, south of Beaumont, where later Capt. A. F. Lucas brought in his phenomenal gusher and opened up the Spindle Top field. He then returned to Austin and completed his paper on the clays of Texas.

Mr. Dumble made two instrumental sections across southwest Texas. The first, beginning at La Costa on the Galveston, Harrisburg and San Antonio Railroad, followed Atascosa Creek and the Nueces River to the San Antonio and Aransas Pass Railroad at Wade, passing through Lytle, Pleasanton, Oakville, Dinero, and Lagarto. The second began at San Diego and was run northward by Gray's and Gueydan's ranches to Tilden, and thence to Pearsall on the International & Great Northern Railroad. He had as assistants Messrs. Singley, Mathias, Leverett, and Posey. Later, Mr. Dumble made the section between San Antonio and Laredo along the International & Great Northern Railroad, and eastward along the Mexican National Railroad to Los Ojuelos, Ochoa, and Pena. Messrs. Taff and Leverett, continuing the work of the previous year, mapped the Cretaceous area west of the Colorado River. Sections were made along its northern boundary between Austin and Fredericksburg and across it from Lange's Mill, Gillespie County, by way of Kerrville and Boerne to the Balcones fault, three miles southeast of Leon Springs, Bexar County.

Professor Cummins, with the assistance of Mr. Drake, traced out the stratigraphic relations of the beds formerly known as Albany or Colorado with those of the Wichita, and found the former to be simply the direct southward continuation of the latter. Later, Cummins and Dumble made a study of the line of Cretaceous capped buttes west of Stonewall in a search for possible Jurassic deposits. This section was continued to the Staked Plains in Garza County, when they turned south to Big Springs. A careful study and large collections were also made of the interesting section at Kent, El Paso County. In the trans-Pecos the work was confined to a trip by Osann and von Streeruwitz for the investigation of the more important eruptives and igneous rocks, of which Osann had found specimens in the collections.

Professor Cragin's work on the Cretaceous collections was continued until June, when he resigned. The study of the Tertiary invertebrates was continued through the year by Professor Harris, who not only determined the forms collected by the survey, but made large collections himself, not only in Texas, but also at type localities in Alabama and Mississippi, and after comparison with the collections in Philadelphia, Washington, and that of Mr. Aldrich, installed the entire collection in the museum, leaving it in the best possible shape for use. He also prepared a monograph on the Texas Tertiary invertebrates, with descriptions and figures of all forms which had been found in Texas.

Professor Hyatt continued his assistance and had a number of forms from the Double Mountain division or Upper Permian horizon for determination, and Prof. E. D. Cope made a number of determinations of vertebrate forms collected during the year. Mr. Charles S. Simpson, of the United States National Museum, studied and described the Triassic Unionidae collected by Cummins in Garza County.

Doctor Melville died in February, and Mr. Dickson continued his work until his resignation in August, when the laboratory was closed.

In addition to the installation of the suite of Tertiary invertebrates, collections of the land and fresh-water shells and of the birds were also placed in the museum.

The fifth annual report was prepared and submitted for publication. The printing board deferred action from time to time and finally declined to order the report printed, on account of the depleted condition of the State treasury. They also refused permission for printing at private expense. The report comprised the following:

Annual Report of the State Geologist, E. T. Dumble.

Report on the Geology and Water Conditions of Southwest Texas, E. T. Dumble.

Report on the Clays of Texas, W. Kennedy.

Report on the Cretaceous Area West of the Colorado River, J. A. Taff.

Report on the Permian of Texas, W. E. Cummins.

Monograph of the Tertiary Invertebrates of Texas, G. D. Harris.

Triassic Unionidae, Chas. T. Simpson.

A Geological Map of the State of Texas, compiled by E. T. Dumble.

Mr. Dumble, in 1902, published a paper in the Transactions of the American Institute of Mining Engineers, entitled Geology of Southwest Texas, containing a portion of the matter in the report submitted with the fifth annual report. Mr. Simpson printed his contribution in the papers of the United States National Museum, and Mr. G. D. Harris published that portion of his work representing new species in the Proceedings of the Philadelphia Academy.

Work of the sixth year (1894).—The corps at the beginning of this year consisted of the State geologist, one geologist (Cummins), and a small office force. With the expiration of the appropriation, February 28, the office force was discontinued.

The last field work under the appropriation included a careful examination of the water conditions along the Texas and Pacific Railway, between San Martin and Kent, on the north face of the Davis Mountains, and the investigation of the San Carlos coal field in El Paso County. The lack of an appropriation, however, did not entirely stop the work, for during the year the following investigations were made by Mr. Dumble as State geologist:

That of the water conditions of a large part of Hall County, including the town of Memphis; a similar investigation of the valley of the Pedernales from Fredericksburg westward; examination of the water conditions of the town of Mexia, in which Professor Cummins assisted; a study of the artesian conditions along the International and Great Northern Railroad from Houston to Groveton; a brief investigation of the asphaltum deposits of Burnett County, in company with Doctor Penrose; a study of the Diabolo Mountain section in the vicinity of the Hazel mine. Professor Cummins assisted in this last and spent the remainder of the season on work in the vicinity of the Eagle Mountains and westward.

The chemical laboratory was reopened, and Mr. Dumble did considerable chemical work during the latter portion of the year in answer to numerous inquiries therefor. In the museum considerable progress was made in the rearrangement and classification of the collections.

The publications based on these examinations were as follows:

Cretaceous of West Texas and Coahuila, E. T. Dumble. Bulletin Geological Society of America, volume 6.

Notes on the Texas Tertiaries, E. T. Dumble, Texas Academy of Science, 1894.

Soils of Texas, E. T. Dumble, Texas Academy of Science, 1895.

Red Sandstone of the Diabolo Mountains, E. T. Dumble, Texas Academy of Science, 1901.

On the inauguration of C. A. Culberson as governor in 1895, A. J. Rose was appointed commissioner of agriculture, insurance, statistics, and history. After an examination of the amount of correspondence and demands for information on matters pertaining to the geological branch, he reappointed Mr. Dumble State geologist, with the understanding that in event of lack of appropriation for salary Mr. Dumble could collect and retain the regular fees for work in return for carrying on the affairs of the department. This arrangement continued during his term of office as commissioner.

The twenty-fourth legislature passed an appropriation for continuing the survey for two years from March 1, 1895, but this was vetoed by Governor Culberson.

During 1895 and 1896 Mr. Dumble investigated and reported on the water supply of the cities of Galveston, Houston, Palestine, Denison, and Taylor, made numerous examinations of mineral deposits in various portions of the State, attended to the very considerable correspondence of the office and completed the arrangement of the collections in the museum. The fees collected for the two years amounted to a little over $3,600.

In March, 1897, Mr. Dumble was appointed consulting geologist for the Southern Pacific Company, after which, until the close of his connection with the department in February, 1899, the work done for the survey was confined entirely to the correspondence.

The legislature which met in 1899 provided for the transfer of the laboratory, library, and collections of the geological survey to the University of Texas, and this was done.

Expenses.—The expenditures of the survey up to December 15, 1888, amounted to $3,983.71:

Salaries of State and assistant geologist	$1,348.87
Salary of State chemist	164.88
Salary of clerks	664.00
Equipment	997.12
Field expenses	785.85
Other expenses	22.99
	$3,983.71

From December 15, 1888, to December 31, 1889, the appropriations and expenditures were as follows:

Balance of first appropriation		$11,016.29
Appropriation Mar. 1, 1889, to Feb. 28, 1890		35,000.00
Expended:		
Salaries	$21,796.28	
Field equipment	731.71	
Field expenses	6,234.48	
Instruments and apparatus	3,479.28	
Furniture and fittings	3,376.93	
Books and maps	403.38	
Laboratory supplies	1,309.86	
Printing	363.50	
Office supplies	161.87	
Incidentals	570.28	
Balance	7,588.72	
		$46,016.29

From January 1, 1890, to December 31, 1890, the appropriations and expenditures were as follows:

Balance on hand Dec. 31, 1889		$7,588.72
Appropriation Mar. 1, 1890, to Feb. 28, 1891		35,000.00
Expended:		
Salaries	$23,851.49	
Field equipment	766.02	
Field expenses	6,104.00	
Instruments and apparatus	318.55	
Furniture and fittings	490.18	
Books and maps	981.78	
Laboratory supplies	927.09	
Printing	371.65	
Office supplies	37.65	
Incidentals	399.63	
Balance	8,340.68	
		$42,588.72

From January 1, 1891, to December 31, 1891, the appropriations and expenditures of the geological survey were as follows:

Balance unexpended, Dec. 31, 1890		$8,340.68
Appropriation Mar. 1, 1891, to Feb. 29, 1892		35,000.00
Expended:		
Salaries	$21,045.61	
Field equipment	617.43	
Field expenses	6,329.36	
Instruments and apparatus	1,346.19	
Furniture and fittings	700.95	
Books and maps	802.93	
Laboratory supplies	635.77	
Printing and engraving	1,998.40	
Office supplies	417.41	
Incidentals	435.70	
Balance	9,010.93	
		$43,340.68

Appropriation for traveling and other expenses of an investigation into the utilization of lignite:

Amount of appropriation	$3,000.00
Amount expended	1,553.75
Balance	$1,446.25

Appropriation and expenditures from January 1, 1892, to December 31, 1892:

Balance unexpended Dec. 31, 1891		$9,010.93
Appropriation Mar. 1, 1892, to Feb. 28, 1893		35,000.00
Expended:		
Salaries	$23,619.05	
Field equipment	501.73	
Field expenses	6,671.61	
Instruments and apparatus	267.10	
Furniture and fittings	3,251.15	
Books and maps	1,176.99	
Laboratory supplied	785.65	
Printing and engraving	1,129.53	
Office supplies	590.83	
Incidentals	853.52	
Balance	5,163.77	
		$44,010.93

Appropriation for traveling and other expenses of an investigation into the utilization of lignite:

Balance	$1,446.25
Amount expended	1,446.25

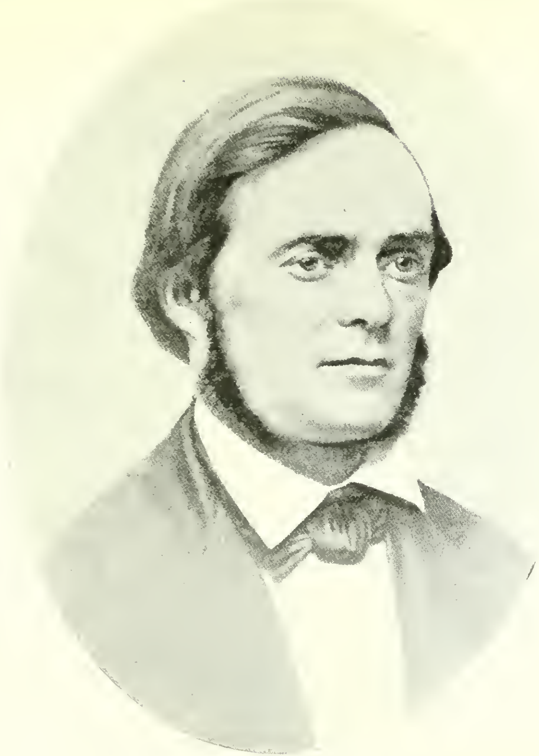
Appropriation and expenditures from January 1, 1893, to February 29, 1894:

Balance unexpended Dec. 31, 1892	$5,163.77
Appropriation Mar. 1, 1893, to Feb. 29, 1894	20,000.00
Expended: Salaries, field expenses, etc	$25,163.77

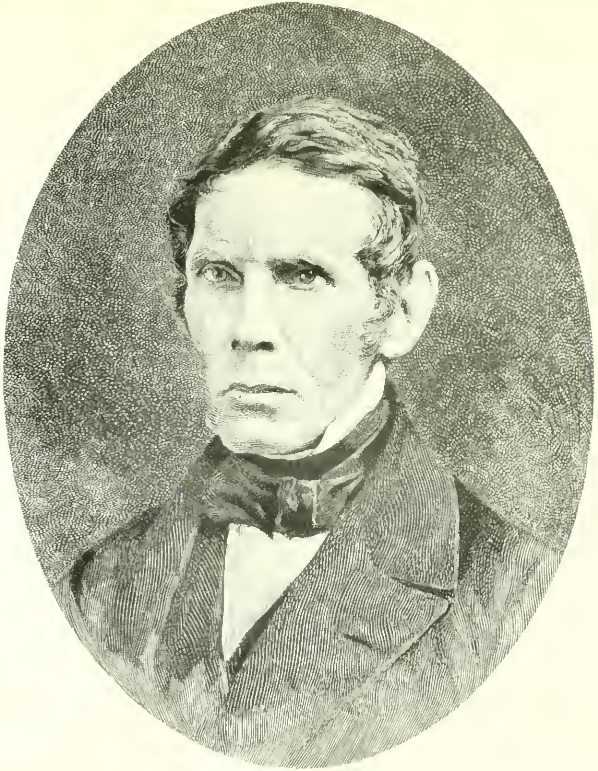
VERMONT.

FIRST SURVEY UNDER CHARLES B. ADAMS AND ZADOCK THOMPSON, 1844–1856.

The matter of a geological survey of Vermont was first brought to the consideration of the general assembly during the administration of Governor Jennison in 1836, and the following year (October session, 1837) the subject was referred to the committee on education, on whose behalf Governor Eaton submitted to the senate a report, an extract of which forms Appendix 5 in the preliminary report on the natural history of the State of Vermont, prepared by Judge Augustus Young in 1856.



Charles Baker Adams, 1845-48



Zadock Thompson, 1845-47

STATE GEOLOGISTS OF VERMONT.

This report contains little that is of interest to-day, with the exception of his remarks relative to the comparative value of topographic and geological work. In discussing which of these two surveys should have precedence in view of the importance of carrying both on together he remarks:

> But as one is not essential to the accomplishment of the other, and as the expense of an accurate topographical survey, carried on only to such an extent would doubtless be deemed advisable, if it were undertaken at all, would be according to the estimates before us, not less than $10,000 or $12.000, the committee, in view of the considerations, * * * are of the opinion that a geological survey should be the first undertaken, leaving the other enterprise to some future period when its execution will be more imperiously demanded by the wants and more clearly justified by the wealth of the State.

Although the subject of the survey was discussed at the succeeding session of the general assembly, the first act relative thereto was not passed until October, 1844, and a second in December, 1853, the one making provision for such a survey and the other providing for its completion. The text of these acts is as follows:

An act to provide for a geological survey of the State. 1844.

SECTION 1. The governor is hereby authorized and directed to appoint a State geologist, who shall have a competent knowledge of scientific and practical geology and mineralogy, and shall be subject to the orders of the governor for the time being and removable at his pleasure.

SEC. 2. The State geologist, with the approbation of the governor, shall from time to time appoint all proper and necessary assistants, fix their compensations, direct them in their labors, and remove them and appoint others whenever it shall be found necessary or expedient.

SEC. 3. It shall be the duty of the State geologist, as soon as practicable, to commence and prosecute a thorough geological and mineralogical survey of the State, embracing therein a full and scientific examination and description of its rocks, soils, metals, and minerals; make careful and complete assays and analyses of the same, and annually, on or before the first day of October, to report to the governor the progress of the work, the most efficient and economical manner of conducting it, and an estimate of the expense for the ensuing year.

SEC. 4. For the purpose of carrying into effect the provisions of this act the sum of $2,000 annually, for the term of three years, is hereby appropriated.

SEC. 5. All claims, under the provisions of this act, shall be presented to the auditor of accounts for allowance, who shall draw orders on the treasurer of the State for the amount he shall find due, equal to but not exceeding in any year the annual appropriation.

Approved October 28, 1844.

An act to provide for completing the geological survey of the State, 1853.

It is hereby enacted by the General Assembly of the State of Vermont, as follows:

SECTION 1. The governor is hereby directed and authorized to appoint Prof. Zadock Thompson, State naturalist, who shall be subject to the orders of the governor for the time being and removable at his discretion.

SEC. 2. It shall be the duty of the State naturalist to enter, as soon as practicable, upon a thorough prosecution and completion of the geological survey of the State, embracing therein a full and scientific examination and description of its rocks, soils, metals, and minerals; make careful and complete assays and analyses of the same, and prepare the results of his labors for publication under the three following titles, to wit:

First. Physical Geography, Scientific Geology, and Mineralogy.

Second. Economical Geology, embracing Botany and Agriculture.

Third. General Zoology of the State.

SEC. 3. Whenever sufficient facts and materials shall have been collected upon the first of the above-named subjects to form a volume of not less than 500 pages, octavo, the State naturalist shall make report thereof to the secretary of state, with an estimate of the size and probable cost of publication, who shall immediately issue a circular addressed to the several town clerks in the State, specifying the nature, size, number of engravings, and estimated cost of the work, and requesting them to post up such circular in their respective offices; also to convey notices of such circular to the public by such other means as they may adopt to receive subscriptions for the work, and within 40 days from the time of their receiving such circular return such subscriptions to the said secretary; and said secretary shall also transmit like circulars to all the publishers of newspapers printed within this State, with a request for gratuitous publication of the same.

SEC. 4. Immediately upon the expiration of the above-named period and the return of said subscriptions the secretary of state shall issue proposals for printing said work, specifying the size and quantity of engravings, style of binding, quality of paper, and number of volumes required, which shall not exceed more than one-fifth the whole number of subscriptions returned; the period within which said work shall be completed, and the time and place for opening bids; and at the said specified time and place the said secretary shall open and examine the bids, and the lowest bid, having due regard to the ability and responsibility of the person making the same, shall be accepted. And the said secretary shall take a bond from the person whose bid is accepted, conditioned upon faithful performance of his said contract, in a sum not less than double the cost of the work. And when the said work shall be completed and accepted by said secretary he shall cause to be sent to the constable of each town such number of volumes as have been subscribed for in such town, with a list of such subscriptions, and each of said constables shall deliver the said volumes, collect the actual cost thereof, and pay over the same into the treasury of the State.

SEC. 5. Whenever sufficient facts and materials shall have been collected and arranged under the second and third titles specified in section 2 the same shall be published in their order, agreeably to the provisions of sections 3 and 4 of this act.

SEC. 6. The sum of $1,000 annually is hereby appropriated for the term of three years, and until otherwise ordered by the legislature of this State, for the purpose of carrying into effect the provisions of this act.

SEC. 7. All claims under this act shall be presented to the auditor of accounts for allowance, who shall draw orders on the treasurer of the State for the amount he shall find due, equal to but not exceeding in any year the annual appropriation.

Approved December 6, 1853.

As will be noted, the survey as proposed had no connection with any other institution and was to be sustained by annual appropriations.

Administration.—Under the act of 1844 Prof. Charles B. Adams, at that time professor of chemistry and natural history in Middlebury College, was appointed State geologist, entering upon his duties on March 1, 1845. He was assisted by Zadock Thompson and the Rev. S. R. Hall, who, according to the law, were appointed with the approbation of the governor. He was also assisted from time to time by Dr. Edward Hitchcock and others. In the report for 1845–46 it is mentioned that Denison Olmsted, jr., was engaged upon chemical work for the survey, and that, upon his decease, which took place August 15, 1846, T. S. Hunt, then in New Haven, was qualified to fill the position.

The salary of the State geologist, as appears from the report of expenses, was $600 a year for the first two years of the survey and $700 for the third. The field assistants, Messrs. Thompson and Hall, appear to have been paid only for the time of actual service, the amount for both, so far as can be learned, being $455 for 1845, $574 for 1846, and $280 for 1847.

The duties devolving upon the State geologist, in virtue of the act of 1844, were to begin and prosecute a thorough geological survey of the State, embracing therein a full and scientific examination and description of the rocks, soils, metals, and minerals, and to make careful and complete analyses and assays of the same, and also to report annually, on or before the first day of October, on the progress of the work.

Although not so stated in the law, it appears to have been understood that a collection of rocks and minerals of the State was to be formed, and in the report for 1846 mention is made of the fact that not far from 7,000 specimens had been obtained "during the present season alone": also in the report for 1847 mention is made of the preparation of eight suites, one of which was for the State collection and the others for the University of Vermont, Middlebury College, for the personal use of Professor Adams; for the medical college at Woodstock; for the medical college at Castleton; for the Troy Conference College at Poultney; and for the university at Norwich.

The legislature made no provision for embodying the facts gathered during the three years of the survey in a systematic report, and with the cessation of the appropriations in 1847 Professor Adams accepted a professorship in Amherst College, Massachusetts. In 1848, Prof. Zadock Thompson was commissioned by the governor to take charge of the collections pending final action by the legislature relative to the completion of the survey, by virtue of the following resolution:

> *Resolved by the senate and house of representatives*, That all collections of minerals, field notes, and all preparations and materials amassed by the

State geologist for a final report upon the geological survey be brought together by some suitable person, to be appointed by the governor, and be deposited in the State house under the care of the State librarian, that nothing may be lost, and that the State may have the benefit of these collections whenever the State shall deem it expedient to prosecute the survey to completion.

Unfortunately, before action was taken on the matter of preparation of the final report mentioned, Professor Adams died.[1]

In the December following the decease of Professor Adams was passed the act given on pages 497–8, providing for the completion of the survey. In this act, it will be noted, botany and general zoology were added to the items to be considered; that is, the survey was to be a general natural history survey. Under this act Professor Thompson was appointed State naturalist.

It was Thompson's desire to carry out systematic investigations and publish them to the world in the form of a physical geography and natural history of the State, which should consist of three volumes, the first devoted to geology, the second to botany, and the third to zoology. It was found, however, that Adams's custom had been to keep his notes in a very abbreviated form, quite incomprehensible to his successors, and Professor Thompson early announced that more labor would be involved in deciphering them than in going over the ground anew. Unfortunately, too, Professor Thompson was himself cut off by death on January 19, 1856, and the second attempt at a survey came to an end.

Up to 1856, then, the entire results of the survey, as made public, amounted to four annual reports by Professor Adams, consisting of 92, 267, 32, and 8 pages, respectively, and the report of Judge Young of 88 pages.

On February 27 following, Mr. Augustus Young was appointed State naturalist to fill the vacancy until the next meeting of the general assembly. Young, however, lived only to publish a report of 88 pages, giving a history of the survey up to date, when he, too, died, and the winter following "another heavy providential disaster fell upon the work in the destruction by fire of the fine collections made by Professor Adams and others—a ruin so complete that probably not 50 specimens remain fit to take a place in the new cabinet." (Hitchcock.)

Expenses.—The expenses under the Adams survey can not be given with absolute accuracy, since the actual expenditures as given cover for but seven months of each year, those for the remaining five months being given in the form of estimates.

Appropriations, 1845–1847, three years, at $2,000 a year	$6,000.00

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[1] Professor Adams died on the Island of St. Thomas, West Indies, January 18, 1853.

Expenditures:

Traveling expenses of principal and assistants	$321.38	
Salary of principal geologist	325.00	
Services of President Hitchcock	75.00	
Salaries of two field assistants	400.00	
Services of occasional assistants	89.43	
Apparatus and expenses at depot of specimens, includcluding shelves, rent, etc	78.68	
Postage and transportation	46.73	
		$1,336.22

The estimates for the remainder of the year, up to Mar 1, 1846, are as follows:

Traveling expenses	25.00	
Salary of principal geologist	275.00	
Services of occasional assistants	55.00	
Barometer, case and packing	68.00	
Expenses of depot of specimens, including rent and fuel	20.00	
Postage and transportation	20.00	
Chemical analyses	200.00	
		663.00
		$1,999.22

The expenses of the geological survey, from Mar 1, 1846, to Oct. 1, 1846, were the following:

Traveling expenses of principal and assistants	358.27	
Salary of principal	350.00	
Salaries of commissioned assistants	324.00	
Services of occasional assistants	90.42	
Services of President Hitchcock	54.00	
Apparatus, engravings, and expenses of the geological depot, including rent, fuel, mineral trays, etc	222.12	
Transportation and postage	64.42	
		$1,463.23

The estimates for the remainder of the year, up to Mar. 1, 1847, were the following:

Traveling expenses	20.00	
Salary of the principal	250.00	
Services of occasional assistants	32.77	
Expenses of the geological depot	20.00	
Transportation and postage	14.00	
Chemical analyses	200.00	
		536.77
		$2,000.00

The expenses from Feb. 26 to Sept. 26, 1847, were as follows:

Traveling expenses	$363.36	
Salary of principal	466.67	
Salaries of commissioned assistants	155.00	
Services of occasional assistants	173.78	
Services of President Hitchcock	25.00	
Apparatus, rent, fuel and light, packing materials, and other expenses of depot	103.67	
Postage and transportation	35.37	
		$1,322.85

The estimates for the remainder of the year, up to Feb. 26, 1848, are the following:

Traveling expenses	$75.00	
Salary of principal	333.33	
Salaries of commissioned assistants	125.00	
Services of occasional assistants	53.76	
Apparatus, rent, fuel and light, stationery, and other expenses of depot	40.00	
Postage and transportation	50.00	
		677.09
		$1,999.94

SECOND SURVEY UNDER EDWARD HITCHCOCK, 1856–1860.

In October, 1856, the general assembly passed the following act with a view of resuscitating the survey:

It is hereby enacted by the General Assembly of the State of Vermont, as follows:

SECTION 1. The governor is hereby authorized and directed to appoint some suitable person State geologist, to complete the geological survey of the State, who shall be removable at the discretion of the governor and another appointed in his stead.

SEC. 2. The State geologist shall, as soon as practicable after his appointment, enter upon the duties of prosecuting the survey with a view to its speedy completion, and may, with the consent of the governor, appoint one or more assistants, who shall be under the direction of the principal and removable at his discretion.

SEC. 3. The State geologist shall make, or cause to be made, such explorations in such portions of the State as have not been thoroughly examined and described in the field books of those heretofore engaged in the survey, and shall make, or cause to be made, such judicious assays or analyses of mineral substances, in addition to those already made, as may be required to determine their economic value. He shall also prepare for exhibition specimens of minerals and other substances designed for the State collection and place the same in the one already commenced in the statehouse.

SEC. 4. It shall further be his duty annually, on or before the second Thursday of October, to make a report to the governor of the progress of the survey, in which he shall report the expenses of the survey for the current year, together with his estimate of the probable amount of funds necessary for its completion. He shall also, as soon as practicable, prepare for publication a final report, embracing therein the physical geography, the scientific and economical geology, and the mineralogy of the State, which, when completed, shall be delivered to the governor, to be laid before the legislature for its action thereon.

SEC. 5. The sum of $1,000 annually is hereby appropriated, until otherwise ordered by the legislature, for the purpose of carrying into effect the provisions of this act.

SEC. 6. All claims under this act shall be presented to the auditor of accounts for allowance, who shall draw orders on the treasurer of the State for the amount he shall find due, equal to, but not exceeding, in any year, the amount appropriated.

SEC. 7. This act shall take effect from its passage.

Approved November 18, 1856.

Administration.—Under this act Prof. Edward Hitchcock was placed in charge of the survey. He was assisted by Albert D. Hager, and his sons, Edward Hitchcock and Charles H. Hitchcock, the same being appointed with the approbation of the governor.

This survey, like its predecessor, had no connection with any other institution and was dependent upon direct appropriations for its sustenance. The entire expense during the four years of its existence amounted to but $4,000, of which $2,542.65 was for salaries and $1,457.35 for traveling expenses and freight. Doctor Hitchcock, himself, received no salary except in 1859 and 1860, in which years it would appear he received $300 and $266.67, respectively. The others received sums varying from $131 to $333.95, as shown in the statement on page 504.

Under Hitchcock's administration the work of exploration was begun in the spring of 1857. The main objects which he announced as to be accomplished were: First, to gain such a knowledge of the solid rocks of the State as to be able to delineate them upon maps and sections; second, to study the loose deposits lying upon the solid rocks and trace out the changes which the surface of the State had undergone; third, to collect, arrange, and name specimens of rocks, minerals, and fossils from every part of the State with a view to forming a State cabinet; fourth, to obtain a full collection for the cabinet of specimens valuable in an economic point of view; and fifth, to identify the metamorphosed rocks of the State with those which have not been thus changed.

The work of measuring sections, collecting specimens, tracing out the formations, and collecting statistics from mines and quarries devolved mainly upon A. D. Hager and C. H. Hitchcock, Mr. Hager giving special attention to the economic geology, while Mr. Hitchcock paid especial attention to the superficial deposits. The survey was assisted in its paleontological work by James Hall, of Albany, New York.

Publications and their distribution.—A final report of the survey under Hitchcock appeared under date of 1859 and 1861 in the form of two quarto volumes of 982 pages, with 36 full-page plates and a colored geological map of the State. It comprised a report on the scientific geology of the State, which was the joint work of Doctor Hitchcock and his assistants; second, a report on the economic geology, by A. D. Hager; third, a report on the chemistry of the survey, by Charles H. Hitchcock; fourth, a catalogue of 2,800 specimens of rocks and 370 minerals, besides several hundred specimens of organic remains, which had been arranged, ticketed, named, and displayed in the State cabinet; and, fifth, a report by Rev. S. R. Hall on the agricultural geology of the State. These were distributed in accordance with the following:

It is hereby enacted, etc.

SECTION 1. It shall be the duty of the trustees of the State library to distribute the geological report, not to exceed 30 numbers in all, to such persons or their representatives as have been officially connected with the survey, or as are recognized in the report as having made scientific literary or artistic contributions thereto.

Approved November 21, 1861.

Resolved by the senate and house of representatives, That each academy in the State shall be entitled to receive from the State a copy of the Vermont Geological Report of 1861, on satisfactory proof being made to the State librarian that such institution has not already received a copy from the State.

Results.—Among the results accomplished he announced as, "first and most important of all," the discovery that the agricultural capabilities of the soils of Vermont were due to the presence "of lime in such a state of natural processes to bring it out in just about the quantity needed by vegetation"; second, that most of the valuable rocks and minerals in Vermont run lengthwise of the State; third, that these mineral treasures, such as granites, marbles, slates, soapstones, serpentines, etc., occur in inexhaustible quantities; and, fourth, that they are of such kind as will be always in increasing demand all over the country.

Expense.—The total expenditures and appropriations of the survey under Doctor Hitchcock, as given in the final report, were as below:

Appropriations, $1,000 a year for 1857, 1858, 1859, 1860	$4,000.00
Expenditures:	
1857, traveling expenses and freight	332.10
1858, traveling expenses and freight	737.25
1859, traveling expenses and freight	188.00
1860, traveling expenses and freight	200.00
Total	$1,457.35
Salaries:	
1857, Mr. Hager	$333.95
1858, Mr. Hager	131.37
1859, Mr. Hager	256.00
1860, Mr. Hager	266.67
1857, Mr. C. H. Hitchcock	333.95
1858, Mr. C. H. Hitchcock	131.37
1859, Mr. C. H. Hitchcock	256.00
1860, Mr. C. H. Hitchcock	266.67
1859, Dr. Edward Hitchcock	300.00
1860, Dr. Edward Hitchcock	266.67
Total for salaries	$2,542.65
Total for traveling and freight	1,457.35
	$4,000.00

In 1864 a futile attempt at resuscitating the State survey was made by the passage of the following:

It is hereby enacted by the General Assembly of the State of Vermont:

SECTION 1. The office of the State geologist is hereby continued, with a view to encourage the further development of the mineral wealth of the State. And it shall be the duty of the State geologist hereinafter named to give counsel respecting the openings to be made in mines and quarries, when desired by the owners thereof, and faithfully to advise and assist all such persons as may employ him in an attempt to discover new mines and quarries, or to encourage the workings of those already discovered.

SEC. 2. The assistant State geologist under the late survey, Albert D. Hager, of Cavendish, is hereby appointed and confirmed as State geologist of Vermont, for the purpose contemplated by this act: *Provided, however,* That in no case and under no circumstances shall such geologist charge or receive from the State anything for expenses or services rendered, but in accepting said office it is understood that he looks to his employers for any compensation that he may reasonably deserve to have for any professional services so by him rendered.

SEC. 3. The geologist shall keep a record of such new facts relating to the geology of the State as shall come to his knowledge, and transmit a copy of the same to the governor, when requested by him, for the use of the State.

SEC. 4. This act shall take effect from its passage.

Approved November 22, 1864.

It could scarcely have been expected that any original work of value would be accomplished under a law which, as a matter of fact, simply threw the influence of the State in favor of private enterprise. So far as publication is concerned nothing whatever came from the appointment and one is not surprised to find among the laws of 1870 the following:

It is hereby enacted by the General Assembly of the State of Vermont:

SECTION 1. The governor shall appoint a State geologist, who shall hold his office until another is appointed in his stead under the act entitled "An act for the appointment of State geologist," approved November 22, 1864, in the place of Albert D. Hager, who has removed from this State; and so much of section 2 of said act as relates to the appointment of said Hager to that office is hereby repealed.

SEC. 2. This act shall take effect from and after its passage.

Approved November 22, 1870.

Under this law the governor gave the appointment of State geologist to Hiram Cutting. Two years later the following acts were passed:

An act providing for additions to the collections of the State cabinet.

It is hereby enacted by the General Assembly of the State of Vermont:

SECTION 1. A sum not exceeding $200 per annum for the next two years is appropriated for the purpose of defraying the necessary expenses of the State cabinet; said sum to be expended by the curator in the collection of such specimens as he may deem of public value and properly labeling the same.

SEC. 2. The auditor of accounts is hereby directed to draw his order on the State treasurer, at such times and for such sums, not exceeding the sum mentioned in section 1 of this act, in favor of the curator of the State cabinet, as shall appear to said auditor that said curator is entitled to receive under section 1 of this act.

SEC. 3. This act shall take effect from its passage.

Approved November 26, 1872.

An act to appoint a State geologist.

It is hereby enacted by the General Assembly of the State of Vermont:

SECTION 1. The governor is hereby authorized and directed to appoint a State geologist who shall have a competent knowledge of scientific and practical geology and mineralogy, and shall hold his office during the pleasure of the governor.

SEC. 2. It shall be the duty of the State geologist to give counsel respecting the openings to be made in mines and quarries when desired by the owners thereof, or any person interested therein, and to faithfully advise and assist all such persons as may employ him in any attempt to discover new mines and quarries, or to encourage the working of those already discovered: *Provided, however,* That in no case and under no circumstances shall said geologist charge or receive from the State anything for said services or expenses except he is directly employed by the governor of the State, but shall look to his employers for any compensation that he may reasonably deserve to have for any professional services so by him rendered.

SEC. 3. The geologist shall keep a record of such new facts relating to the geology of the State as shall come to his knowledge and transmit a copy of the same to the governor, when required by him, for the use of the State.

SEC. 4. All acts and parts of acts inconsistent with the provisions of this act are hereby repealed.

SEC. 5. This act shall take effect from its passage.

Approved November 26, 1872.

From these acts it is evident that the State had no intention of favoring to any extent work other than that of caring for and building up the State cabinet. Apparently the effort, so far as survey was concerned, was nearly as barren of results as was the previous one. Cutting, however, did publish brief reports, in pamphlet form in 1872, 1874, 1876, and 1878 as curator, and which included more biological than geological material.

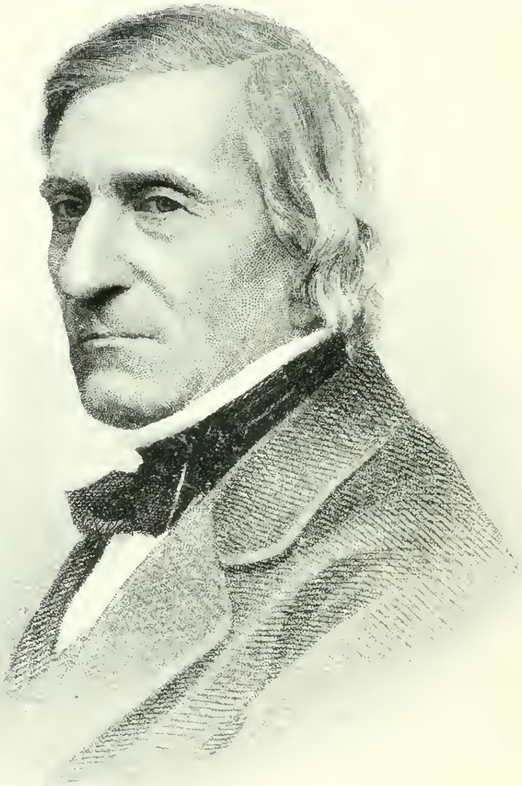
THIRD SURVEY UNDER G. W. PERRY AND GEORGE H. PERKINS, 1886–1900.

In 1886 the matter of a survey came once more before the assembly with the following result:

It is hereby enacted, etc.

SECTION 1. Section 164 of the Revised Laws is hereby amended so as to read as follows:

SECTION 164. The governor shall biennially appoint, with the advice and consent of the senate, a State geologist, who shall be curator of the State cabinet, and shall hold office until his successor is appointed. The person appointed shall have a competent knowledge of scientific and practical geology and mineralogy.



William Barton Rogers

STATE GEOLOGIST OF VIRGINIA, 1835-42.

SEC. 2. This act shall take effect from its passage.
Approved November 18, 1886.

Under this law the appointment of State geologist and curator of the State cabinet was conferred upon Rev. G. W. Perry, who held the office until obliged to resign, through ill health, in 1898. In 1896 the law was modified as below:

It is hereby enacted by the General Assembly of the State of Vermont:

SECTION 1. The State geologist shall during the next two years personally inspect the mines and quarries now in operation within the State, also deposits of minerals of economic value which have not been opened or developed.

SEC. 2. He shall incorporate in his next biennial report the results of such inspection, showing as far as possible the quality and quantity of our marble, granite, slate, soapstone, copper, and other mineral products; the extent of our mines and quarries, and the methods of working the same. He shall also make as full a statement as possible of the undeveloped mineral deposits of promising value, incidentally reporting unused water powers in the vicinity of said deposits.

SEC. 3. For the prosecution of this work there shall be appropriated the sum of $1,500 annually for the period of two years.

Approved November 24, 1896.

Under these enactments Mr. Perry, as stated by Dr. George H. Perkins, collected a considerable amount of material for a report, which, however, he was unable to complete on account of long-continued illness. He therefore resigned early in the summer of 1898 and was succeeded by the present active incumbent, Dr. George H. Perkins, above mentioned. Up to and including that of 1900 two reports had been issued by Doctor Perkins—one on the marble, slate, and granite of the State (1898) and the second on its mineral resources (1900). As noted in the act, the present survey receives an appropriation of $1,500 annually.

VIRGINIA.

The first direct move in favor of a geological survey of the Virginias would seem to have been the result of a letter written by Peter A. Brown, of Philadelphia, the corresponding secretary of the Geological Society of Pennsylvania, to His Excellency, John Floyd, governor of Virginia. This letter, dated September 30, 1833, enlarged on the supposed importance of the mineral resources of the State and the great scientific discoveries which might be made through a systematic investigation under State auspices. The letter was transmitted by Governor Floyd to the legislature, together with his message of 1833–34, and the following recommendation:

Whilst engaged in the improvement of the State by constructing roads for the safe and speedy transportation of the products of agriculture, we ought not to be unmindful of the great wealth which lies buried in the earth, which only requires the examination of men of science to bring before the country and make known its value and usefulness to capitalists, who would be induced to engage in fitting it for commerce, thereby creating new sources of wealth. It is well known that Virginia affords, perhaps, the most extensive mines of iron of any other country of the same extent, and fine specimens also of gold, lead, copper, plaster of paris, gypsum, and inexhaustible mines of bituminous coal, besides many valuable earths which constitute the finest manures, as will more fully appear from the inspection of a communication herewith placed before you, having been received from a gentleman of much scientific knowledge and reputation.

No action appears to have been taken during this session, but during that of 1834–35 memorials were received from Morgan, Frederick, and Shenandoah Counties praying for such a survey. These were referred to a select committee, which made an exhaustive report[1] and presented the bill, a transcript of which is given below:

A bill to authorize a geological reconnoissance of the State, with a view to the chemical composition of its soils, minerals, and mineral waters.

Be it enacted by the general assembly, That, as soon after the passage of this act as it may be convenient, it shall be the duty of the board of public works to appoint a suitable person to make a geological reconnoissance of the State, with a view to the general geological features of our territory and to the chemical composition of its soils, minerals, and mineral waters, and to report to the next general assembly a plan for the prosecution of a geological survey of the State, together with such facts as may have come to his knowledge during the progress of said reconnoissance, illustrative of any advantages likely to accrue from a more complete examination.

Be it further enacted, That the said board of public works shall have authority, provided they should deem it expedient, to employ a topographical engineer to aid the geologist to be employed in the reconnoissance aforesaid.

Be it further enacted, That the said board of public works shall have authority to allow to the geologist and topographical engineer who may be employed under the provisions of this act such compensation as they may deem reasonable for each to be paid out of any unexpended moneys in the treasury: *Provided*, That such compensation shall not exceed in the aggregate the sum of $3,000.

This act shall commence and be in force from the passing thereof.

This bill, after some discussion and incidental modification, was made a law March 6, 1835. The following is the text of the bill as it finally passed:

1. *Be it enacted by the general assembly*, That as soon after the passage of this act as may be convenient it shall be the duty of the board of public works to appoint a suitable person to make a geological reconnoissance of the State, with a view to the general geological features of our territory, and to the chemical composition of its soils, minerals, and mineral waters, and to report to the next general assembly a plan for the prosecution of a geological survey of the State, together with such facts as may have come to his knowledge during the progress of said reconnoissance, illustrative of any advantages likely to accrue from a more complete examination.

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[1] Given in detail in The Virginias of November, 1882, p. 167.

2. *Be it further enacted*, That the said board of public works shall have authority to allow to the geologist who may be employed under the provisions of this act such compensation as they may deem reasonable, to be paid out of any unexpended moneys in the treasury: *Provided*, That such compensation shall not exceed the sum of $1,500.

3. This act shall commence and be in force from the passing thereof.

Under this bill Prof. William B. Rogers, then teaching in William and Mary College, was employed to make the reconnoissance provided for, and submitted his report to the house of delegates in January, 1836. This was favorably received and led to the passage of the following law providing for a systematic geological survey:

An act to provide for a geological survey of the State, and for other purposes, passed February 29, 1836.

1. *Be it enacted by the general assembly*, That the president and directors of the board of public works be, and they are hereby, required, as speedily as may be, to cause a complete and detailed geographical survey of the entire territory of this State to be made and executed, and a careful and accurate chemical examination and analysis of the various soils which may be found in different parts thereof, as also of the principal ores, marls, saline and mineral waters within said territory.

2. *Be it further enacted*, That for the purpose of making such survey and analysis it shall be lawful for the said president and directors to employ a competent and skillful geologist, and an assistant geologist, if need be; and may also engage the services of or employ a topographical surveyor, whose duty it shall be to make such observations and admeasurements as may be found necessary in the preparation and construction of the geological map of the State hereinafter provided for, and to perform such other labors connected with the general purposes hereby intended as the geologist may from time to time prescribe and direct. In addition to the duties before mentioned to be performed, the geologist who may be employed by virtue of this act shall also ascertain by accurate barometrical observations the height of the principal mountains in the State; and in the progress of the surveys and examinations hereby directed, shall collect and preserve all such specimens of rocks, fossils, ores, mineral compounds and organic remains, as shall tend to exemplify the general geological structure of the State, or be in any wise useful or interesting. The specimens, so far as practicable, shall be collected in sufficient number to authorize a distribution of a suite thereof to the principal institutions of learning in the State, if it shall hereafter be found expedient to make such distribution.

3. *Be it further enacted*, That said geologist shall annually, and before the 10th day of January in each year, make report to the president and directors of the board of public works of his progress in the work hereby authorized and required, accompanying said reports with such profiles and maps, together with a glossary of scientific or technical terms, as may be useful in illustrating the same; which reports, profiles, and maps it shall be the duty of the said president and directors to lay immediately before the general assembly.

4. *Be it further enacted*, That for the purpose of defraying the expenses which may be incurred under this act a sum not exceeding $5,000 per annum be, and the same is hereby, appropriated, to be apportioned among the several persons

hereby authorized to be employed, in such manner and in such amount as to the president and directors of the board of public works shall seem best, to be paid upon their certificate out of any moneys in the treasury not otherwise appropriated, upon the warrant of the auditor of public accounts: *Provided,* That the amount to be paid to the geologist and the assistant geologist shall not exceed the sum of $3,000 per annum, to be apportioned and divided between them in manner above directed, and the sum to be paid to the topographical surveyor shall not exceed $1,000.

5. *Be it further enacted,* That when the entire work hereby contemplated and provided for shall have been fully completed, it shall be the duty of the geologist in charge thereof to make a general and final report thereon, embracing in such report, in detail, the result of all surveys, examinations, and discoveries which shall have been made, geological, chemical, and topographical, and all other matters connected therewith, which may be considered by him as likely to be in any manner useful to the public or interesting to science. He shall also construct and prepare for engraving a complete geological map of the State, showing not only the general geological structure thereof, but plainly and accurately delineating the stratification of its principal rocks, and the position and boundary of all the mineral deposits which may now be known or be ascertained by the investigations which shall have been made, accompanying said map with such a series of sections or profiles as may be necessary to a proper exhibition of the geology of the region to which they may relate. The final report, together with the map and the accompanying sections and profiles, the president and directors of the board of public works shall communicate to the general assembly as soon as may be, to be printed, engraved, published and disposed of in such manner as to the said general assembly shall seem proper.

6. *Be it further enacted,* That the mineral materials and other specimens which may be collected during the operations of the geologist and others who may be engaged with him, shall be carefully preserved in some convenient apartment of the library room, until otherwise provided for. A complete catalogue of such specimens and materials shall be made out, and preserved in the same apartment, showing the name, locality, and general properties and value of each, as ascertained by the analysis to which it may have been subjected, and referring to the corresponding number which shall be affixed to the specimen itself.

7. This act shall be in force from and after its passage thereof.

This act was in 1841 repealed, though subsequent appropriations were made for completing the work already in hand, as below:

And be it further enacted, That the act entitled "An act to authorize a geological reconnoissance of the State, with a view to the chemical composition of its soil and mineral waters," and all acts and parts of acts amendatory thereof, shall be and the same are hereby repealed, from and after the 1st day of January next.

To the geological survey, to defray charges and expenses incurred, although the acts authorizing the survey have been repealed, from and after the 1st day of January, 1842, $4,000.

To the geological survey to defray charges and expenses incurred, although the acts authorizing the survey have been repealed from and after the 1st day of January, 1842, being the balance of the appropriation for last year, to complete the geological survey, and not drawn on the 1st of October last, and therefore chargeable on the current year, $1,083.33.

It will be noted from the wording of the law that, although Professor Rogers was, at the time of the authorization of the reconnoissance of the survey, connected with William and Mary College in the capacity of professor of chemistry and natural philosophy and later as professor of natural philosophy in the University of Viriginia at Charlottesville, it was entirely independent of either institution and was placed directly under the board of public works and to be sustained by annual appropriations.

Administration.—It would naturally follow from the preceding that Professor Rogers should be appointed State geologist under the act of 1836, and the appointment was promptly conferred upon him by the board of public works. Considerable difficulty, seems to have been experienced in the securing of proper assistants, as there was naturally a great lack of trained observers at that date.

In 1836 Robert Empie Rogers, a brother of Professor Rogers, was appointed; and in 1837 a second brother, James B. Rogers, who was at the time professor of chemistry in the Cincinnati Medical College. In the report for this year mention is made also of Charles B. Hayden, an assistant in charge of work in the northern division, and Prof. W. E. A. Aikin, in the southern division. In 1838 J. Slade and George W. Boyd were employed in addition, Mr. Slade as an assistant to J. B. Rogers, and Mr. Boyd to Professor Aikin. In 1839 the corps was the same, with the exception of C. Briggs, appointed to the position made vacant by the resignation of W. E. A. Aikin, but in 1840 James B. Rogers and Charles B. Hayden resigned, their places being filled by the appointment of Samuel Lewis and Dr. Thomas Ridgway. Doctor Boyd died before the close of the season, and Mr. Lewis resigning, two vacancies were created in the corps, one of which was filled by the reappointment of James B. Rogers. M. Wells assisted Messrs. Briggs and Ridgway during a part of the season of 1841.

Expenses.—Concerning the salaries paid no information is available other than that given in the law, in which it is expressly provided that the amount paid to the geologist and assistant geologist shall not exceed the sum of $3,000 a year, and that the sum to be paid to the topographical surveyor shall not exceed $1,000.

The entire expense of the survey, so far as can be determined from the published reports, was some $40,000. It is apparent from Rogers's statement[1] that $36,000 had been expended up to January, 1841, and a subsequent act of the legislature made an additional appropriation of $4,000.

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[1] Life and Letters of W. B. Rogers, p. 179.

Museum.—Paragraph 6 of the law of 1835 provided for the collection and preservation of specimens and materials to be preserved in some apartment of the library room until otherwise provided for.

Publications.—Antagonism to the survey manifested itself as early as 1839, and in 1841 the law creating it was repealed, though the unexpended balance of the appropriation was permitted to be utilized in the finishing of reports. Six annual reports, beginning with 1836 and ending with 1841, were issued. No final report had been prepared, nor was provision made for the same, although Professor Rogers and the friends of the survey made earnest efforts in this direction. Even as late as 1854 it appears from the published correspondence that Professor Rogers was in Richmond and appeared before the legislature urging an appropriation of $2,400 for the completion of the work. and although the bill passed the senate, it failed in the house. A compilation of the original reports, comprising an octavo volume of upwards of 800 pages. with colored sections and a geological map, was in 1884 issued by D. Appleton and Company, of New York City, under the editorship of Jed. Hotchkiss, a mining engineer of Staunton, Virginia.

WISCONSIN.

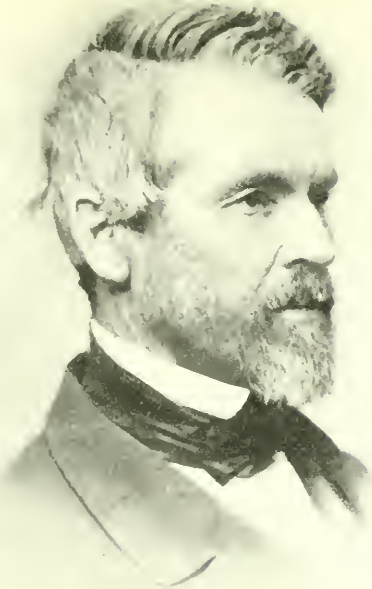
FIRST SURVEY UNDER EDWARD DANIELS AND J. G. PERCIVAL, 1853–1856.

The mineral resources of Wisconsin had been in part investigated by the survey of David Dale Owen in 1839–40, under direction of the General Land Office. The first survey under State auspices was inaugurated in accordance with the following enactment:

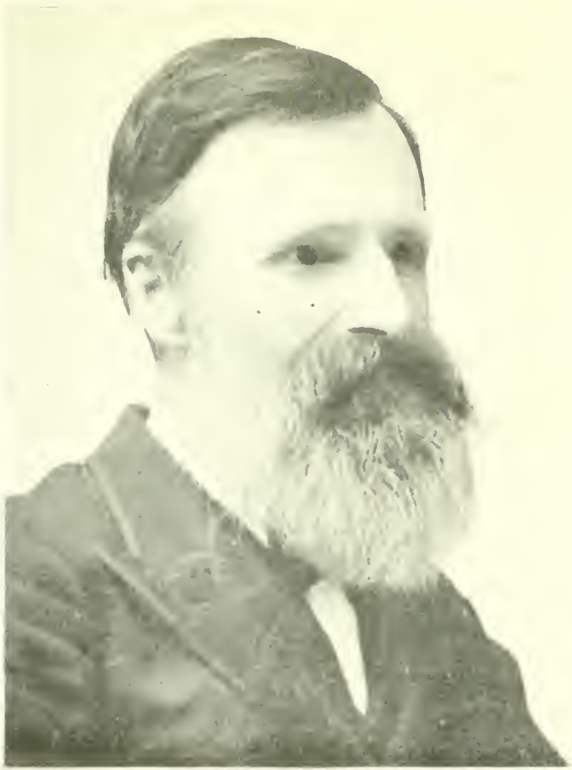
The people of the State of Wisconsin, represented in senate and general assembly, do enact as follows:

SECTION 1. The governor of this State is hereby authorized, as soon as may be after this act shall take effect, to appoint a State geologist, who shall be a person of competent scientific and practical knowledge of the science of geology and mineralogy; and the said State geologist shall, by and with the consent of the governor, appoint one suitable person to assist him in the discharge of his duties, who shall be a skillful analytical and experimental chemist.

SEC. 2. It shall be the duty of the said State geologist and his assistant, as soon as may be practical after their appointment, to commence and carry on with such expedition and dispatch as may be consistent with minuteness and accuracy, a thorough geological and mineralogical survey of this State, with a view to determine the order, succession, arrangement, relative position, dip of inclination, and comparative magnitude of the several strata or geological formations within this State, and to discover and examine all beds or deposits of ore, coal, clay, and such mineral and earthy substances as may be useful or valuable, and to perform such other duties as may be necessary to make a full and complete geological and mineralogical survey of the State: *Provided*, That it shall be the duty of said State geologist to complete his survey of that portion of the State known as the "lead mines" before commencing the survey of the remainder of the State.



Increase Allen Lapham, 1873-75



Edward Daniels, 1853-54

STATE GEOLOGISTS OF WISCONSIN.

SEC. 3. It shall be the duty of the said assistant to make full and complete examinations, assays, and analyses of all such rocks, ores, soils, or other substances as may be submitted to him by the State geologist for that purpose, and to furnish him with a detailed and complete account of the results so obtained.

SEC. 4. It shall be the duty of the State geologist, on or before the first Monday of January in each and every year, during the time necessarily occupied by said survey, to make an annual report of said survey and the progress thereof, accompanied with such maps, drawings, and specimens as may be necessary and proper to exemplify and elucidate the same to the governor of this State, who shall lay a copy of such report before the legislature.

SEC. 5. It shall be the duty of the said State geologist to cause to be represented on the map of the State, by colors and other appropriate means, the various areas occupied by the different geological formations in the State, and to mark thereon the localities of the respective beds or deposits of the various mineral substances discovered, and on the completion of the survey to compile a memoir of the geology and mineralogy of the State, comprising a complete account of the leading subjects and discoveries which have been embraced in the survey.

SEC. 6. It shall be the duty of the said State geologist to forward to the governor of this State, from time to time during the progress of said survey, such specimens of the rocks, ores, coals, soils, fossils, and other mineral substances discovered and examined, properly labeled, as may be proper and necessary to form a complete cabinet collection of specimens of geology and mineralogy of the State; and the said governor shall cause the same to be deposited in the cabinet of the university, there to be preserved for public inspection.

SEC. 7. For the purpose of carrying into effect the provisions of this act the sum of $2,500 is hereby annually appropriated, to be drawn quarterly, for the term of four years, to be expended under the direction of the governor. The salaries of the said State geologist and his assistant shall not, however, commence until they have respectively entered upon the execution of their duties; and upon the completion of said survey, and all the duties connected therewith, the same shall wholly cease and determine.

SEC. 8. This act shall be printed immediately after the passage thereof, and when so printed shall be in full force.

Approved March 25, 1853.

Administration.—Under this law the appointment of State geologist was first given to Edward Daniels, who, however, held the office for but a single year, being superseded in 1854 by Dr. J. C. Percival. Mr. Daniels, in accordance with the expressed provision of the law, devoted his attentions first to the lead regions in the southwestern part of the State. He was assisted by H. A. Tenney and I. A. Lapham (volunteer paleontologist). The chemical work of the survey was performed by Dr. A. A. Hayes, then State assayer of Massachusetts. A single report, bearing date of 1854, in the form of an octavo pamphlet of but 80 pages, all told, comprises the results of this work. As noted, Daniels was succeeded by Percival, who likewise confined himself largely to economic problems. During the first year he visited "all the considerable diggings from the south line of the State to a line drawn from east to west, north of

Cassville, Beetown, Potosi, Platteville, Mineral Point, Yellowstone, and Exeter, and from the Mississippi to the east part of Green County."

His report for this year was in the form of an octavo pamphlet of 101 pages, with an outline map showing the location of the principal ore "diggings." In the season of 1855 he first visited the iron mines at Iron Ridge, Dodge County, Hartford, Washington County, and at Marston on the Little Baraboo, Sauk County, after which he recommenced the examination of the lead districts, completing the work June 30. The remainder of the season, till December 8, was employed in a reconnoissance of the State for the purpose of forming a general idea of the stratigraphy.

While engaged in preparing his second report, recording the operations of the year, he was taken ill and died on May 2, 1856. The report as issued was in the form of a small octavo of 111 pages.

Expense.—The total appropriation for the survey, as indicated in the act, amounted to but $7,500.

SECOND SURVEY UNDER JAMES HALL, 1857–1860.

The geological survey having been left unfinished by the death of Percival, a new act was passed in March, 1857, of which the following is a transcript:

An act to provide for a geological and agricultural survey of the State.

The people of the State of Wisconsin, represented in senate and general assembly, do enact as follows:

SECTION 1. James Hall, of Albany, New York, and Ezra S. Carr and Edward Daniels, of Wisconsin, are hereby designated and appointed commissioners to make a geological, mineralogical, and agricultural survey of this State, embracing a scientific and descriptive survey of the rocks, fossils, and minerals of the State; full and complete assays of the ores and minerals, also of the soils and subsoils, with the classification and description of the same and their adaptation to particular crops, and the best methods of preserving and increasing their fertility. They shall also make a full collection of the rocks, ores, and minerals, and whatever illustrates the economic geology of the State, and deposit the same in the rooms of the State university or such other place as may be provided for the same, constituting a museum of practical and scientific geology. Said commissioners shall also make full collections of soils, native fertilizers, cultivated and other useful plants, constituting a museum of practical and scientific geology, and deposit the same as aforesaid.

SEC. 2. Said commissioners shall arrange and distribute the functions of such survey by mutual agreement, and employ such assistants as may be deemed by a majority of them necessary to carry on the work.

SEC. 3. The governor of this State shall make a written contract with each of the commissioners aforesaid, expressly stipulating and setting forth the nature and extent of the service to be rendered by each and the compensation therefor, including the expenses of the department of the survey under charge of each commissioner. Such contract shall expressly provide that the compensation to each commissioner shall be at a certain rate per annum, to be agreed upon, and not exceeding the rate of $2,000 per annum; and that payment will be made only for such part of each year as such commissioner may actually be engaged in the discharge of his duty as commissioner.

SEC. 4. Should the board of regents of the State university neglect to make suitable provision for the accommodation of the collections, it shall be the duty of the commissioners, with the advice and consent of the governor, to provide suitable rooms elsewhere in the city of Madison.

SEC. 5. In case of a vacancy or vacancies occurring in the commission by this act provided, the governor shall appoint some suitable person or persons to fill the same; and he may remove any member for incompetency or neglect of duty, after giving such member due notice of the charge against him, and a full opportunity to be confronted with his accuser and to make his defense.

SEC. 6. To carry out the provisions of this act the sum of $6,000 per annum for the term of six years is hereby appropriated, to be drawn from the treasury quarterly on warrant of the governor, and paid to the persons entitled to receive the same; which sum shall be in full for salaries of commissioners, assistants, rent of room, and all other expenses incident to said survey, exclusive of printing the annual reports of said commissioners.

SEC. 7. This act shall take effect and be in force from and after its passage.

Approved March 3, 1857.

Administration.—It would appear from correspondence to which the author has had access that Mr. Carr was the prime instigator in the passage of this bill, though working in more or less collaboration with Charles Whittlesey and Edward Daniels. In a letter from Carr to Hall, in anticipation of the passage of the bill, under date of January 28, 1857, the directorship of the survey is offered the latter, who, in a reply dated February 3 following, said that he could not apply for the same so long as Daniels was a candidate, as he had already agreed to give him his support. Under date of March 26 Carr again wrote Hall:

> The governor and all others who are interested in the survey look to you as the responsible man in geology. The governor understands Daniels and said to me that you and myself, being a majority, could arrange matters.

The effective force of the survey as finally organized under this act was James Hall, Ezra S. Carr, and Edward Daniels, as noted in the bill of its establishment. The salaries, though not absolutely fixed by law, were by it limited to a sum not exceeding $2,000 a year, and it was further expressly stipulated that payment should be made only for such part of each year as the commissioner should be actually engaged in the discharge of his duties.

The actual survey did not, according to O. W. Wight,[1] begin until the year following (1858). It was first proposed by Hall that the three commissioners named contribute equally out of their allotment to defray the expenses of Charles Whittlesey in making a survey of the northern part of the State. The plan does not seem to have been fully carried out, apparently through a lack of collaboration on the part of Daniels, who was evidently an element of discord from the start, and who secured from the governor a special contract for himself regardless of the interests of Hall and Carr. Wight states, however, that Messrs. Hall and Carr, at their own expense, employed Col. Charles Whittlesey to explore the country between the Menomenee and Oconto Rivers as a preliminary to a more extended survey to the northward. In the spring of 1859 an engagement was entered into with J. D. Whitney, who had been employed as chemist on the Iowa survey, whereby he was to make a survey of the lead region—a work which, it may be incidentally noted, was carried out.

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[1] Annual Report of Geological Survey of Wisconsin, 1875, p. 69.

The tripartite commissioner arrangement designated under the first law evidently did not work out satisfactorily, as is apparent from the following:

EXECUTIVE OFFICE,
Madison, February 17, 1858.

To the Hon. the Senate:

I have received from Mr. E. Carr and Mr. James Hall, appointed by the law of 1857, with Mr. Edward Daniels, to make a geological survey of this State, a communication on the subject of that survey, and giving their reasons for not forming and organizing the commission contemplated by that law. In further answer to the resolution of the senate calling on me for information on that subject I deem it proper to transmit the same herewith for your consideration.

ALEX. W. RANDALL.

To His Excellency Hon. Alexander W. Randall, Governor of Wisconsin:

The undersigned members of the commission appointed by the law, approved March 3, 1857, to make a geological and agricultural survey of the State, beg leave to present to your excellency the following statement as an explanation of the reasons why they have not been actively engaged in performing the duties required by the said act:

After the passage of the bill authorizing a geological and agricultural survey of the State, Mr. Daniels assumed such a position toward it that Mr. Hall and myself believed we could not honorably or usefully be connected with it, unless the contracts clearly and definitely fixed the nature and extent of the service to be rendered by each, in accordance with the third section of the act. We wished that the work of the survey, which each one was to perform, and the amount of the appropriation which each one might use in accordance with the provisions of the act to accomplish the same, should be determined by the contracts. We insisted that each one should be limited to an equitable proportion of the appropriation ($2,000 per year), and that if more than this was expended in any department it should be a matter of mutual agreement. This was the difference between Mr. Daniels and the other members of the commission, he insisting that the survey was chiefly instituted for his benefit, and that the control and management of the same rightfully belonged to him. He was unwilling to be limited in his contract in the use of the appropriation.

Mr. Hall came to Madison on the 1st of May, at the suggestion of the governor and other members of the commission to make the arrangements and contracts necessary to carry them out, Mr. Daniels having written from Kansas that he would be present on that date. Mr. D. did not appear. and the conference between the governor, Mr. Hall, and myself resulted in agreeing upon the above as a basis of the contract. The division of the work of the survey was also agreed upon, and was essentially the same as was afterwards embodied in the contracts drawn June 19. This division of labor was based upon an equitable division of the funds, that each one should have the means of working out, in accordance with the provisions of the act, that portion of the survey which he was made responsible for. No contracts were entered into at the time, as it was desired that Mr. Daniels should first be consulted.

Mr. Daniels, on his return, objected to the above basis, for the reasons already stated, and steadily refused his assent until the 19th day of June, when he came to me and professed his cordial assent, desiring me to go with him to the governor's office and have the contracts executed. The governor expressed his satisfaction at the result, and called in Mr. J. C. Hopkins to draw up the contracts, to whom we stated the division of labor and the limitation in the use of the funds agreed upon. Attention was particularly directed to this latter point, as it was understood that this was the point of difference which had prevented the commission from being organized at an earlier date. When I called at the office of Mr. Hopkins the next morning I found the contracts were drawn up without the limitations, and what was still more surprising, Mr. Daniels, without consulting any other member of the commission, had caused his own to be executed and taken it away with him. The governor had signed them on the previous evening and left town. I at once protested to Mr. Daniels against the whole proceeding as contrary to the express agreement of the commission to which he had just assented. As he persisted in retaining his contract, neither Mr. Hall or myself have had anything further to do with the matter, believing the proceedings to have been illegal.

It is true that the division of labor as specified in the contract drawn by Mr. Hopkins is essentially the same as agreed upon (see Senate journal of January 29), but it is equally true that this division was based upon a condition wholly ignored in the contracts.

The contracts as drawn, and under which Mr. Daniels has since the 19th of June drawn about $2,000 from the State treasury, I believe to be not in accordance with the provisions of the act, because—

1st. They do not accord with the second section, which requires that the functions of the survey shall be distributed by mutual agreement, and that such assistants shall be employed as a majority of the commission shall deem necessary.

2d. Mr. Daniels's contract allows him, in addition to his salary, which is fixed by law, at the rate of $2,000 per annum, for the time spent in the service of the State, all expenses incurred by him in the prosecution of the same, including expenses of assistant. (See contract in Senate journal of January 29.) It is easy to see that under the head of expenses in Mr. Daniels's contract he might, so far as any limit is concerned, use up the greater part of or even the entire appropriation. This contract is in violation of the second section of the act, which requires that the assistants employed shall be such as a majority of the commission shall decide upon: and of the third section, which requires that the contract shall determine, not only the nature but the extent of the compensation, and the expenses of the department of the survey under the charge of each commissioner. There are no limitations in Mr. Daniels's contract of the amount of the appropriation which he may use as a part of his "necessary expenses," while the act expressly stipulates that the contracts shall set forth the extent of the expenses made by each commissioner.

It is but justice to the majority of the commission to say that they have been ready ever since the passage of the act to organize the commission and take contracts in accordance with its plainly expressed provisions, and that they have declined to take the contracts as drawn, because they believed them not in accordance with the provisions of the act, and also for the reason that if Mr. Daniels, or any other member of the commission, was thus allowed an unlimited use of the funds, they could not with any security enter upon any plan of operations creditable to themselves or the State.

Respectfully, yours,

E. S. Carr.

The foregoing statement, signed by Professor Carr, I certify to be correct so far as my own action and views are concerned and the events of which I have any personal knowledge. The agreement of a majority of the commission with the governor as to the basis of the contracts to be drawn, as set forth in the preceding statement, has been entirely disregarded, and I have always maintained that the course pursued in the execution of the same is not in accordance with the intent of the law, and is therefore illegal.

I am, very respectfully, your obedient servant.

James Hall.

Madison, *February 16, 1858.*

Referred to committee on State affairs.

In addition to the above, Daniels, it would appear, made an attempt, which, however, failed, at getting through the legislature a bill making himself chief geologist. Carr states further, in a letter dated May 19 of this year, that a bill was introduced and passed in the house repealing the law establishing the survey. This was, however, killed in the senate, and with the understanding that Hall should go on with the work. On May 30 Carr wrote Hall that new contracts had been drawn up, allotting to each of the three commissioners the sum of $2,000 a year to be utilized " in accordance with the previous provisions of this act."

Whittlesey during at least a part of 1859 was working under a private contract, his expenses ($1,500) being met by moneys advanced by Hall and Carr. Nevertheless, whether from philanthropic or other motives, he wrote to Hall proposing that the latter resign in his (Whittlesey's) favor. Hall naturally declined, stating (under date of March 29, 1859):

I should have little objection to resigning, but if I do so it must be entirely and absolutely and without any further connection with the survey whatever. The affair is an awkward one and I regret that I ever became connected with it in any way, but as it is, I shall try a little longer for a better state of things.

And again, under date of April 8:

I intend to see something tangible done before I leave the work.

There was apparently no way out of the disagreeable and wholly unsatisfactory tangle, but by an entirely new deal and by the act given in full below, approved April 2, 1860, Hall was made principal of the commission:

An act to perfect the geological survey of the State.

The people of the State of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. James Hall, of Albany, New York, is hereby constituted and appointed principal of the geological commission established by chapter 40 of the General Laws of 1857, and is hereby vested with such general control and supervision of the geological survey of the State as is not already expressly reserved to the several commissioners designated in said chapter.

SEC. 2. It shall be the duty of the said James Hall to make a written contract with J. D. Whitney, which contract shall be approved by the governor, providing for the completion within the present year of his survey and maps of the lead mines of the southwestern portion of the State; which maps shall include the whole of such district and shall be constructed upon a uniform scale. A contract shall also be made in the same manner with Charles Whittlesey for the continuance of his survey of the mineral regions of Lake Superior.

SEC. 3. For the purpose of carrying into effect the provisions of the preceding section the governor is hereby authorized, upon the presentation of the proper vouchers, to draw from the treasury such portion of the sum appropriated by said chapter 40 of the General Laws of 1857, as was not drawn previous to the signing of the contracts with the commissioners on the 29th day of May, A. D. 1858; and all that part of said appropriation hereby authorized to be drawn by the governor, which shall not be required to carry into effect the provisions of the contracts as provided in the preceding section, shall be appropriated for the engraving of maps and drawings to illustrate the surveys therein provided for.

SEC. 4. This act shall take effect and be in force from and after its passage and publication.

Approved April 2, 1860.

After the passage of this act Carr wrote to Hall, informing him of the condition of affairs and stating that the sum of $4,500 remained unexpended from earlier appropriations.

Although not so stipulated in the act, the same was passed with the understanding that not less than $1,500 of this sum should be used in the exploration of the northern part of the State, and that the expense of engraving the map should also be paid from it.

In accordance with section 2 of the law, Hall entered into contracts with Whitney and Whittlesey, as below:

Memorandum of an agreement made and entered into this 1st day of May, in the year 1860, in accordance with section 2 of chapter 334 of the Laws of Wisconsin, approved April 2, 1860, between James Hall, of the first part, in behalf of the people of Wisconsin and subject to the approval of the governor of said State, and Josiah D. Whitney, jr., of the second part, as follows:

To provide for the completion within the present year of his survey and maps of the lead mines of the southwestern portions of the State, which maps shall include the whole of such district and shall be constructed upon a uniform scale.

The party of the second part agrees to make all the necessary surveys and perform all the field work in the lead region in the southwest part of Wisconsin and the adjacent country required for the completion of a geological map of said region, which shall embrace what is known as the lead region of Wisconsin, Iowa, and Illinois, showing the position and relation of the lead crevices, the geological structure of the country, and all the information needful to accompany such a map; and that the map now partially completed shall be finished and ready for the engraver by the 1st of August of this year.

The said party of the second part also agrees to make the necessary surveys for the completion and also to complete a map of the region between Dubuque, Galena, and Shullsburg, on a larger scale than the one above specified, to be called a crevice map, showing the direction, length, etc., of all the lead crevices known in that portion of the lead region embraced in the map, and that the map shall be completed and ready for the engraver on or before the 1st day of November, 1860.

The said party of the second part likewise agrees to prepare a report upon the entire lead region, to accompany the maps aforesaid, which report shall contain a full description of the country embraced within the limits of the maps, so far as its geological structure is concerned, and all that related to its mining or mineral interests. with such sketches, diagrams, and other illustrations as he may deem proper for the same, the original drawings and diagrams for which shall be furnished by himself ready for the engraver. The said report and maps shall constitute a part of the report upon the geological survey of Wisconsin, to be printed in the same form and in the manner which shall be designated by the governor.

This report the party of the second part agrees to have completed and ready for the printer on or before the 31st day of December, 1860, and he agrees either himself to superintend the printing of the same, so far as reading and correcting proofs, etc., or to provide a competent person to do it.

In consideration of the services and labor above specified, the party of the first part agrees to pay to the party of the second part the following sum, as specified—namely, $500 on the signing of this contract or on its approval by the governor; $1,000 on the 1st day of June, 1860; $1,000 on the completion of the maps and report, and their delivery to the party of the first part. These several sums shall be accepted in full for all services performed and labor performed or to be performed under the direction of the party of the first part in connection with the report and maps specified.

These several sums specified shall be paid by a certificate of the party of the first part to the governor, setting forth that the conditions of the contract have been fulfilled and asking his warrant upon the treasurer of the State for the payment of the same. The provisions and requirements of section 2 of chapter 332 of the General Laws of 1860, approved April 2, 1860, and made a part of this contract.

Memorandum of an agreement made and entered into this 12th day of June, in the year 1860, in accordance with section 2 of chapter 334 of the Laws of the State of Wisconsin, approved April 2, 1860, between James Hall, of the first part, in behalf of the people of the State, and Charles Whittlesey, of the second part, as follows:

The party of the second part agrees to proceed to the south shore of Lake Superior in the State of Wisconsin, and to make, for the continuance of his survey of the mineral regions of Lake Superior, a careful geological survey of the country lying between the Montreal River on the east and the easterly branches of Bad River on the west, or so much thereof as he is able to perform during the present season, and to lay down upon a map the limits of the rock formations and designate the same by colors; to make a report upon the same which shall embrace as full and detailed account of his rocks and minerals and a description of the geological structure of the country, as he shall be able to do from the observations made.

The said party of the second part agrees to deliver the said map and report completed to the said party of the first part on or before the first day of January, 1861.[1]

The said party of the second part likewise agrees to make all the necessary collections of rocks, minerals, and ores to illustrate the geology and mineralogy of said district of country.

For the services herein specified the said party of the first part agrees to pay to the party of the second part, with the approval of the governor and to be drawn from the sum appropriated by the law cited, the sum of $1,500, $500 of which is to be paid on the signing and delivery of this contract, $500 on the 1st of November next, and the remaining $500 on the delivery of the map and report aforesaid, the same being in full for all services and expenses of the party of the second part.

Furthermore, the provisions and requirements of the second section of chapter 334, of the General Laws of A. D. 1860, approved April 2, 1860, are made a part of this contract.

Matters still did not work smoothly, though Whitney completed his survey and report on the lead region. The outcome of the arrangement with Whittlesey was less satisfactory. He complained of unfair treatment and that money appropriated for his work was diverted. His connection with the Quartermaster's Division of the Army in 1861 would appear to have interfered with his duties as geologist, but not to have dampened his ambition; and his final report, as received by the governor, seems to have been quite unsatisfactory.

In 1861 the legislature passed an act providing for the publication of 1,000 copies of the reports (Hall's and Whitney's), but included an item repealing the act of establishment; also a joint resolution requesting the commissioners to surrender their contracts. The repealing act the governor refused to sign. A copy of a new agreement made under this act, as found among Mr. Hall's papers, is given below:

This agreement made this 7th day of June, A. D. 1861, between James Hall, geologist, resident of the State of New York, party of the first part, and Alexander W. Randall, governor of the State of Wisconsin, on behalf of said State, party of the second part, witnesseth, that said party of the first part, for and in consideration of the several conditions, agreements, and obligations, herein below mentioned, agreed on and incurred by said party of the second part, and between both parties, agrees to deliver to said party of the second part, in the city of Madison, capital of Wisconsin, on or before the 1st day of January, next, 1,000 copies of Hall's first volume of the geological report of the State of Wisconsin, confined mainly to the lead regions, and to contain not less than 450 pages; and said volume shall embrace a chapter on the general geology of the State and its relations to the geology of the surrounding States, with the details of the geology, mineralogy, and mining thereof, and shall be the same size (but it shall have the number of pages above stated) and in all respects as to type, paper, and binding equal to the Iowa geological report, with all necessary maps and illustrations.

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[1] "Provided that the analyses required for the work shall be completed in time to be incorporated in the report." This clause is inserted before the execution of the contract.

And said party of the second part agrees that when said copies as aforesaid are delivered as aforesaid, and duly accepted by him on behalf of the State, he will pay at the rate of $3 per volume for said report by delivering to said party of the first part, his, said governor's warrant, on the State treasurer for the sum of $3,000, which shall be payment in full for all of said 1,000 reports so delivered and accepted.

It is hereby mutually and further agreed by and between said parties that in case said reports do not in all respects expressly meet the requirements of this contract and the law hereinafter mentioned, the said party of the second part, or the State, shall be under no obligations to accept said report, nor shall any liabiltiy or account thereof exist against the State.

And, lastly, that chapter 263 of the General Laws of Wisconsin for the year 1861, entitled "An act to authorize the purchase of 1,000 copies of the first volume of the geological reports of this State" is herein referred to and made a part of this agreement, in imposing conditions and consequences on the party of the first part, except where said law is inconsistent herewith.

Misunderstandings continued to arise, the details of which it is impossible to now ascertain and the causes of which can only be surmised. The following letter gives Professor Hall's version of the matter:

ALBANY, *October 5, 1861.*

DEAR SIR: I have just now been apprised by Mr. Watson that you decline to pay any money on account of the geological survey. I am surprised and quite unprepared for such a decision. Last spring I heard something of a determination to suspend the work, but after making inquiries I learned that there had been no action and I went on as usual; and am under engagements to pay money for the field work, more than $300 being due to Mr. Hale from the September quarter's salary, and I must pay him nearly as much more by the 1st of January.[1]

After the passage of the law relating to publication I went on preparing the materials, and, as you are aware, have signed a contract to deliver a completed volume of not less than 450 pages with maps, etc. My engagements for this work are all made and the printing is going on. The maps and sections are to be delivered to me on the 9th of December, and I intend to have the volumes delivered in Madison on or before the 1st of January, 1862.

I feel that the completion of this volume is of the utmost importance for the credit of the survey, for those who have authorized it and those who have executed it, and I feel quire sure that its publication will quiet much of the complaint against the survey, and will at last show that some good work has been done.

There has been much labor to prepare this report for the press, and I have also worked at the paleontology, and although there was no appropriation I have had drawings and engravings made; and I send proofs of two plates that you may see the evidences.

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[1] Of this latter sum I have an agreement with Doctor Carr by which he will pay a portion from his salary.

To pay for the work of the publication I need the small amount of money coming to me from these quarterly payments, and if I do not get it I shall be seriously embarrassed. Your decision places me in a very unpleasant position with the responsibilities which by your sanction I have assumed, and I beg that you will reconsider the matter and sustain me till January, when I can present the printed report and the whole matter may be then referred to the legislature. I am quite sure that you will be far better satisfied to have the work now in progress completed and the report published, for we will then have something as a record. To complete this work at my own expense and without the sums due me from the State would ruin me entirely; and if your decision remains, I have to choose between this and to stop and share in a disgrace which will fall equally on all concerned for not accomplishing a work which had been authorized and agreed upon, and for the failure of which the public will never hold us excusable.

The work has been carried on under your own direction, and I have sought your advice and sanction in all matters. Two years since I would have gladly resigned and by your advice alone I remained in my connection with the survey. A continuance of a few months longer, with the small sums I may draw, can not materially injure the State, and you have my assurance of a satisfactory result.

It is my present intention to leave here as soon as the work of printing and other matters are in a satisfactory condition, and I expect to be in Madison about the 1st of November. I hope to be able to see you then; and in the meantime, and as soon as practicable, desire to know if I can draw the amount of the September quarter's pay.

I am, very respectfully, your obedient servant,

(Signed) JAMES HALL.

To His Excellency, ALEX. W. RANDALL,
Governor, etc.

The legislature of 1862, incidental to the excitement of the Civil War, repealed the law authorizing the survey, whereupon Carr and Daniels abandoned the field. This, however, Hall refused to do, contending that he had a contract under seal with the governor, according to the provisions of the law, and that legislation could not annul it. He, therefore, continued his work and completed that which had been originally assigned to him in the division among the three commissioners.

Expenses.—Details of expenditures under this survey are not now available. The original bill authorizing the work appropriated $6,000 a year for six years. The act of April 2, 1860, provided that all of this appropriation not required to carry into effect the provisions of the contracts which had been entered into should be appropriated for the engraving of maps and drawings. It would seem safe to assume, therefore, that the entire amount, $36,000, was utilized, and no more, as there are found no records of further appropriations.

Publication.—Hall's first report as superintendent of the survey, as indicated by the letter of transmittal, bore the date of December 24, 1860.[1] This consisted of an octavo pamphlet of but 52 pages, three pages of which are related to the general work of the survey, the remainder being given up to descriptions of new species of fossils. The manuscript of Whitney's report on the lead region was, according to this author, submitted in October, 1860, but printing was not begun until a year later and was finished in January, 1862. As issued, this report formed a volume of 455 pages, of which the first 72 consisted of an introductory chapter by Hall on the physical geography and geology of Wisconsin, and included a catalogue of the paleozoic fossils of the State. One thousand copies of this were printed under an act of the legislature, dated April 15, 1861. The second volume of Hall's report, it is stated, was prepared and submitted to the governor in December, 1862. The latter, however, did not lay the same before the legislature until it was called for by a resolution dated February 7, 1863. It appears to have never been printed. The following letters, explanatory of Hall's views of the matter, seem worthy of reproduction in full:

WASHINGTON, D. C., *January 11, 1864.*

Hon. ALEXANDER W. RANDALL.

DEAR SIR: In making the statement which you suggested in relation to the geological survey of Wisconsin it is scarcely necessary for me to go back to the original law and the organization of the survey. The law was imperative and in all respects binding upon the individuals accepting positions under it, and I believe you will recollect that I was from the outset desirous of avoiding all difficulty, and on that account insisted on a distinct specification of the duties and responsibilities I was about to incur.

After agreeing to the division of labor and signing the contract with the State I devoted myself, as far as the means at my disposal would permit, to the work before me, while the passage of a supplementary law increased my duties and responsibilities as well as my personal expenses without any additional compensation. It is scarcely necessary to recapitulate in this place, as all the acts and arrangements were done with your knowledge and approval.

The first volume was ordered to be published during your administration, and the manner and style of publication specified. This was accomplished, and copies sent to your successor in office and placed in the hands of members of the legislature in February, 1862. At the same time a committee was appointed to inquire into and report upon the publication of the second volume, for which I showed them the materials prepared and gave an estimate of the cost. The publication was recommended by the governor to the committees of both houses, who met in the executive chambers, and these committees sanctioned the plan. So favorably had the committee looked upon the matter in several meetings that there seemed no doubt as to their recommendation, and by the advice of Mr.

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[1] The copy of this printed report in the library of the United States National Museum was the property of F. B. Meek, and bears the following, in pencil, on the margin: "First 16 pages, pub. February, 1861. Pages 17 to 32, inclusive, pub. Nov. 10, 1861. Remainder at a later date—December, according to Hall."

Hopkins, chairman of the senate committee. I returned to Albany to forward the remaining copies of the first volume and to prepare for the publication of the second volume. Within two weeks after I left Madison the legislature passed some resolutions reflecting upon the course of the geological commission and at the same time passed an act repealing the law for the geological survey without giving any party an opportunity to be heard in explanation. The nature of the original law, I dare say, you will remember. This law authorized contracts with certain parties and required an investigation by the governor before any person could be dismissed.

This act repealing the law prevented the drawing of any money by the governor on account of the survey, and though I was compelled to go twice to Wisconsin after this, and to continue investigations already begun, I was unable to draw any pay from the State under my contract, or in any other way.

Notwithstanding all this, I carried on my investigations in preparation for the second volume, in accordance with my contract, and have not ceased to work at the collections already made for the illustration of the report on the paleontology of the State. The subject of publication was before the legislature during the last session, but they declined to take any action in the matter.

I have in my possession the manuscript and reports, maps, and diagrams of Colonel Whittlesey upon the Menomonee region, and upon the iron region of Lake Superior, also a report upon the drift of the eastern part of the State.

In the department of paleontology I have prepared descriptions of fossils, and at my own expense have had a considerable number of drawings made to illustrate them, and some engraving done in anticipation of the order for publication. The materials in my hands are sufficient to make a volume as large or larger than the one already published. This volume will require the engraving of some maps and about 30 plates of fossils. It would be of great value and interest to the people of Wisconsin and would be prized in all the libraries of the country, as well as among all scientific persons and all students in geology. There can be no question as to the value of the matter I have prepared, and there should be no question as to the desirableness and importance of publishing this work. The efforts of Wisconsin to secure a geological survey have been so often thwarted in one way or another that now when an opportunity offers of making a respectable and creditable conclusion of the work there should be no hesitation on the part of the legislature. The results of the investigations are ready for publication, which is the very condition so long desired by the people and the legislature, and if they would obtain the benefits of the survey the publication must be made.

In the present attitude of the affair I have been deprived of the money actually due me, and, moreover, have been compelled to expend money in carrying on the work and in going to Madison on several occasions, not contemplated in the beginning of the work and subsequent to the repeal of the law.

Although I believe and am so advised legally that my claim against the State under my contract is good and can be sustained, I would much prefer that the legislature, taking an enlightened view of the matter, should order the publication of the results and fulfill the agreement on the part of the State as I have done mine.

As the matter now stands I am placed in the awkward position of holding in my possession materials belonging to the State, while the act of the legislature has deprived me of all connection with the State or power to act in the premises. The extensive collections of geological specimens and fossils are chiefly in my possession (some part of them having been returned to the university). These should by all means be properly labeled and placed in the university cabinet. Of a considerable part of the collection there are duplicates, which might be made into series for one or two other institutions if required. I believe that such a plan of distribution would be of great service to the interests of education in the State.

Something should be done, at least so much as to relieve me from this position, if nothing more. To do this would simply be to pay the amount due me and take custody of the materials in my possession.

In reference to the first volume, 1,000 copies only were published, while a State of the extent and population of Wisconsin should have had at least 2,500 copies.

I have, at considerable expense to myself, preserved the lithographic stones on which the large maps were engraved in order to save expenditure in reengraving should another edition of the volume be ordered.

I can do no more than I have done without further authority, and to give this some legislative action will be necessary.

Should any point require fuller statement or explanation I shall be most happy to forward it to yourself or to anyone else.

I am, with great respect, your obedient servant,

(Signed) JAMES HALL.

ALBANY, N. Y., *January 20, 1864*.

Notwithstanding the repeal of the law, I did not feel myself exonerated from the fulfillment of my contract and continued my work in the preparation of the materials in my hands for publication. I even went so far as to have drawings made and some engravings done for the second volume.

In December last received a letter from Mr. I. A. Lapham saying that he had consulted some of the newly elected members of the legislature in reference to the matter and they were desirous of having the second volume published and the collections labeled and sent to the university. I have replied to this letter.

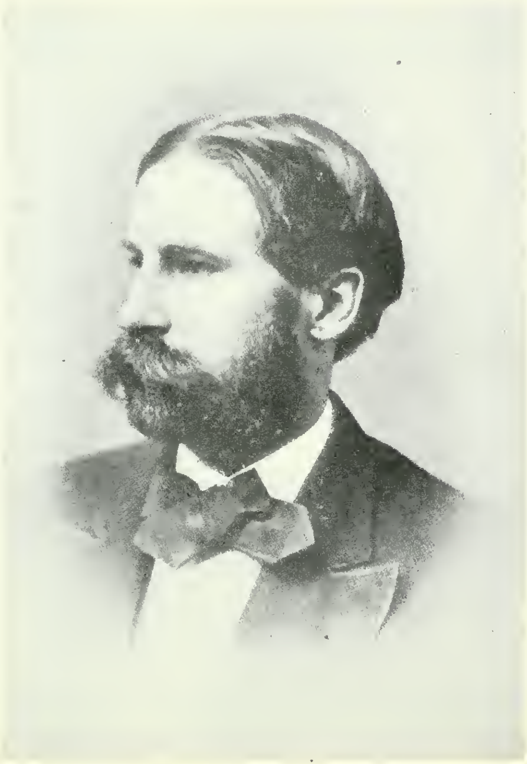
I have in my hands extensive collections of fossils which ought to be properly labeled and placed in the cabinet of the State university, where they would be valuable for study and comparison. The course pursued by the legislature has inflicted an injury upon me by depriving me of a year's salary due under my contract, and then causing me to incur expenses which were in no way connected with my duties under this contract. Besides this, I am deprived of the opportunity of publication, and this is one great object of an investigator. At the same time the people of the State are deprived of the information collected during the survey, and for which their money has been paid. The present condition of the affair creates complaint and dissatisfaction on all sides, for I certainly feel that I have been wronged, while by no act of mine the people have been deprived of what they had a right to expect from me, and which, so far as I could do, I have prepared to bring before them—waiting only the action of the legislature to order publication.

(Signed) JAMES HALL.

JULIUS T. CLARK, Esq.

In 1865, and again in 1866, futile attempts were made at getting a bill through the legislature that should relieve Hall and bring matters to a satisfactory conclusion. As late as 1868 finds Hall writing the governor's secretary as follows:

THOMAS CROWDER CHAMBERLIN, STATE GEOLOGIST OF WISCONSIN, 1876-79,



ROLAND DUER IRVING, ASSISTANT STATE GEOLOGIST, 1876-79

ALBANY, *January 30, 1868.*

CHAS. KNICKERBOCKER, *Secy. etc.*

DEAR SIR: Your favor of the 17th was received by me on my return from Washington this week. The story of the Wisconsin survey is soon told. I went into it by request of the governor and legislature and under a contract provided for in the law. After the first volume was published and a part of the copies delivered in Madison, the second volume in progress and some engraving done, the legislature, in a fit of spleen, repealed the law. The principal cause of this was, I have no doubt, because we did not recommend deep mining in the lead region.

By this act of the legislature I was left about $2,500 out of pocket; that is, my salary for one year and $500 paid for engraving, etc. I have made overtures for some settlement of my claim, but have not succeeded. I have the materials—that is, manuscript, some lithographed plates, etc.—and have within the last few years had other plates lithographed. I have now about 22 plates available for this work, and 20 more would make a fair completion of the volume. None of these have been paid for by Wisconsin, and of course will have to be considered in any arrangement to be made.

The manuscript is, of course, my own, the State having paid for nothing. I likewise hold some boxes of specimens which I collected while engaged in the work, and these would go to the State on completion and payment of the work.

You can judge for yourself of the temper and disposition of the legislature, and whether you could secure the appropriation necessary to pay for the work.

I presume that Professor Carr, of the university, can give you some information, and perhaps the president of the university may be interested to have it completed.

If you conclude to do anything and will let me know how I can help the matter I will do so cheerfully.

I am, very truly yours,

(Signed) JAMES HALL.

Nothing satisfactory seems to have been the outcome of all attempts until 1873. Fragmentary correspondence which has passed under the writer's eye indicates that Whittlesey had kept up a spasmodic and not very amicable correspondence on survey matters and that the latter had aspirations, not realized, of himself sometime becoming State geologist.

THIRD SURVEY UNDER LAPHAM-WIGHT-CHAMBERLIN, 1873–1879.

The third attempt at a geological survey of Wisconsin was made under the following authorization, approved March 19, 1873:

An act to provide for a complete geological survey of Wisconsin.

The people of the State of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. The governor is hereby required to appoint, by and with the advice and consent of the senate, a chief geologist, who shall be a person of known integrity, thorough practical and scientific knowledge of the sciences of geology and mineralogy, and, upon recommendation of said chief geologist, the governor shall appoint one or more assistants, not exceeding in number four, one of whom shall be a skillful analytical chemist and assayer; and the chief geologist and his assistants to constitute a geological corps, whose duty it shall be to make a thorough and complete geological, mineralogical and agricultural survey of the State, and topographical surveys of such_portions as may be deemed by the corps to need them for the thorough completion of the work: *Provided*, That if the appointment of the chief geologist be made during the recess of the senate, such appointment may be confirmed at the next session thereof.

SEC. 2. The survey shall have for its objects:

1st. An examination of the geological structure of the State, including the dip, number, magnitude, order and relative position of the various strata; their richiness in minerals, metallic ores, clays, mineral waters, fertilizers, building stones, and other useful materials; the value of such materials for economic purposes, and their accessibility for mining and manufacture.

2d. Accurate chemical analyses and assays of the various ores, clays, peats, marls, building stones, etc., discovered by the State.

3d. A careful topographical survey of the lead region, for the purpose of ascertaining as far as possible the amount of denudation and the exact position of the mining ground at each locality; also careful barometrical observations on the relative elevation and depression of various parts of the State.

4th. An examination of soils and subsoils, and observations upon the animal and vegetable productions of the State with reference to its agricultural interests.

SEC. 3. It shall be the duty of said geological corps, in the progress of the examinations hereby directed, to collect such specimens of rocks, ores, fossils, minerals, etc., as may be necessary to exemplify the geology of the State. Sets of these specimens shall be deposited with the Wisconsin Academy of Sciences, Arts, and Letters, and the State university, and with each one of the incorporated colleges of the State, and with each of the normal schools, provided application be made to the chief geologist before the commencement of field work.

SEC. 4. It shall be the duty of the chief geologist and his assistants, on or before the first Monday in January in each year during the continuation of the survey, to make to the governor a report of the progress and results of the survey, accompanied by such maps, profiles, and drawings as may be necessary to exemplify the same, which reports the governor shall lay before the legislature.

SEC. 5. As soon as the progress of the survey will permit the chief geologist shall begin, and on completion of the survey shall complete, a final report, including the results of the entire survey, accompanied by such drawings and topographical maps as may be necessary to illustrate the same, and by a single geographical map showing by colors and other appropriate means the stratification of rocks, the localities of the beds of mineral deposits, and the character and extent of the different formations.

SEC. 6. To carry into effect the provisions of this act the sum of $13,000 for each year, until the completion of the said survey, is hereby appropriated, to be drawn from the treasury on warrants from the governor as needed, which shall be in full for all expenditures except printing of reports. The salary of the chief geologist and the salaries of the assistant geologists shall be fixed by the governor, and shall be for services actually performed and time actually spent in the work. The balance of the sum hereinbefore appropriated shall be used in such manner as shall best promote the purposes of this act.

SEC. 7. The survey shall commence the 1st of June next, or as soon thereafter as practicable, beginning with the counties of Ashland and Douglas, and the entire survey shall be completed within four years from and after its commencement.

Approved March 19, 1873.

It will be noted that the survey authorized by this act was independent of any other institution and was to be sustained by annual appropriations. This law, with the additions and amendments given below, continued in force until 1879, though, owing to the unfortunate clause relative to the necessity of a confirmation of the governor's appointment by the senate, the early results were not what one had a right to anticipate.

Administration.—Under the law of March 19, 1873, Increase A. Lapham was appointed chief geologist, receiving his commission on April 10 following. On the 29th of the same month Roland D. Irving, Thomas C. Chamberlin, and Moses Strong were, upon the advice of the chief geologist, appointed as assistants. Also W. W. Daniells was engaged as chemist.

To Professor Irving was assigned the duty of beginning a survey of the iron and copper ranges of Ashland and Douglas counties, with instructions to give particular attention to the question of the age of the red sandstone and the accompanying shales, to that of the Archean rocks, and to the disturbances of the strata in the vicinity of the ore-bearing rocks. He was assisted by F. B. Jenney, E. T. Sweet, and James Munro.

To Professor Chamberlin was assigned that portion of the State lying immediately west of the line of outcrop of the Niagara or Clinton rocks, from the south line of the State through the counties of Walworth, Jefferson, Dodge, Fond du Lac, Calumet, and Outagamie, to the southern limits of the crystalline Archean rocks in Shawano County. He was assisted by L. C. Wooster, F. H. King, N. D. Wright, Samuel Shaw, and G. L. Merriman.

To Mr. Strong was assigned the survey of the lead region, the work to include a careful topographic survey, for the purpose of showing the denudation of the superior strata, that so evidently had occurred, and the exact position of the mining ground at each locality, with particular reference to the rock formation in which the ore was found. He was assisted by A. D. Conover and J. W. T. Crawford.

Unfortunately, as it proved, for the progress of the work, political influences intervened, and in February, 1875, Lapham was succeeded as chief geologist by O. W. Wight. The corps of assistants, however, remained the same, with the exception of the appointment of Gustavus Bode as chemist in place of Daniells, resigned.

The work of the year would seem to have consisted, so far as the chief geologist was concerned, in a reconnoissance begun about the middle of August of the northern portion of the State "for the general purpose of ascertaining the nature and amount of work to be done to complete the survey in 1876." In this work he was assisted by E. T. Sweet.

Wight held the position for but one year, and in his turn was succeeded, in February, 1876, by T. C. Chamberlin, by whom the survey was finally carried to completion. Under the latter's administration the working force of the survey was organized as follows:

Corps: T. C. Chamberlin, chief geologist; R. D. Irving and M. Strong, assistant geologists; W. J. L. Nicodemus, topographical assistant.

Local and special assistants: W. W. Daniells, chemist; Gustavus Bode, chemist; T. B. Brooks, geologist; Charles E. Wright, iron expert; R. P. Whitfield, paleontologist; P. R. Hoy, ichthyologist and entomologist; F. H. King, ornithologist; L. C. Wooster, local assistant; A. C. Clark, local assistant.

Field and other assistants: D. Caneday, A. D. Conover, F. H. Brotherton, I. M. Buell, C. S. Douglas, E. M. Hill, C. S. Bacon.

Under Chamberlin's administration work was continued in the northern and northwestern portion of the State during the first six weeks of the season of 1876; a tract of some 25 townships, situated in Buffalo, Pepin, and Pierce counties, was explored, and careful examinations made for evidence of geological changes within the Quaternary period. Later the copper series were investigated by a party under Moses Strong and the announcement made that the so-called cupriferous series extended in a nearly uninterrupted chain across the northwest portion of the State.

Irving continued his work in Ashland County and Wright in the Penokee District. A. C. Clark was also engaged in making observations along the line of the "military wagon road survey."

The invertebrate fossils collected during this period were placed in the hands of R. P. Whitfield, who recognized among them upward of 150 species entirely new to science. The reptiles were studied by P. R. Hoy; the birds, with especial reference to food habits, by Mr. King.

Field work for the season of 1877 was begun by E. T. Sweet in Bayfield and Douglas counties. Moses Strong, who during the previous season examined a belt extending from the St. Croix Falls, northwestward to the vicinity of Lake Superior, began work in the area lying between this and the one studied by Mr. Sweet. This work was, unfortunately, cut short by his death by drowning, which took place on August 17 in one of the rapids of the Flambeau River. To overcome the delay incident to this accident, two new parties were organized, one under the direction of F. H. King, to which was entrusted the examination of the valley of the Flambeau River, and the other, under F. H. Brotherton, was charged with the exploration of the territory on the west side of the Chippewa River. Irving continued his work in the Lake Superior region. Wright was, during this season, prevented by his duties as commissioner of mining statistics from taking the field. The area previously assigned him was, therefore, examined by Chamberlin, the chief geologist, assisted by A. D. Conover. L. D. Wooster continued his work in St. Croix, Dunn, and adjacent counties, and A. C. Clark in the north central portion of the State. T. B. Brooks and C. E. Wright worked in the Oconto, Pine River, and Menomonee iron districts, while the chemical work, as before, was in the hands of Gustavus Bode. The invertebrate paleontology remained mainly in the hands of R. P. Whitfield, while J. S. Newberry studied the fossil plants. Doctor Hoy and Mr. King continued as in the previous year, while W. F. Bundy made a study of the crustaceans.

This survey was notable in that the microscopic investigations of rocks by means of thin sections was an important feature. This work was performed by A. A. Julien, R. D. Irving, R. Pumpelly, C. E. Wright, and Arthur Wichman, the last of Leipzig.[1]

The act establishing the survey provided for its continuance for but four years, or until the 1st of June, 1877. Through an act passed March 20, 1878 the time was extended until March 31, 1879, but the appropriation was reduced to $5,000. The following is the text of this act:

An act relating to the geological survey of the State of Wisconsin, and amendatory of chapter 292 of the laws of Wisconsin for 1873, entitled "An act to provide for a complete geological survey of Wisconsin, and to repeal chapter 137 of the General Laws of 1870," entitled "An act to provide for the survey of the lead district, making maps, and collecting statistics from the same," and chapter 136 of the General Laws of 1872, amendatory thereof, and chapter 36 of the laws of Wisconsin for 1877, amendatory thereof.

The people of the State of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. Section 6 of chapter 292 of the Laws of Wisconsin for 1873, is hereby amended by striking out the words "thirteen thousand dollars for each year until the completion of said survey," where the occur in the second and third lines of the section, and inserting the words "five thousand dollars," so that the sentence shall read as follows: To carry into effect the provisions of this act, the sum of five thousand dollars is hereby appropriated, to be drawn from the treasury on warrants of the governor, which shall be in full for all expenditures except printing of reports.

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[1] It will be remembered that Hawes's work on the micropetrology of the rocks of New Hampshire was also published in 1878. The first important work of this nature in America was Zirkel's report on the rocks of the fortieth parallel, which appeared in 1876. Caswell's report on the rocks of the Black Hills was published in 1880.

SEC. 2. Section 7 is so amended as to read as follows. The survey shall be completed by March 31, 1879, and all salaries shall cease on that date; but this act shall not debar the members of the geological corps from performing voluntarily the functions of their office, and of supervising the publication of said reports: *Provided*, Said reports are presented at the earliest practicable date: *And provided*, This clause shall not be construed as authorizing any claim to compensation for such voluntary service.

SEC. 3. This act shall take effect and be in force from and after the 31st day of next May.

Approved March 20, 1878.

During the remaining months of the survey's existence the energies of nearly all were concentrated on practical problems, those selected as most essential being the study of the Oconto iron district, the completion of the survey of the Penokee iron range, and a continuation of the so-called crevice survey of the lead region. Irving brought to completion his final report on the eastern portion of Lake Superior. Chamberlin, in company with A. D. Conover, made a reconnoissance of Polk and Burnett counties, with particular reference to the drift deposits. Brooks continued and brought to completion his work in the Menomonee iron region.

Expenses.—The act establishing the survey limited the expenses to $13,000 a year for four years. The act of November 20, 1878, extended the time for two years with appropriation of $5,000 a year. This would bring the total cost of the survey, exclusive of publications, up to $62,000. The cost of the latter, by the act of March 6, 1876, was limited to a sum not exceeding $25,000.

Collections and museum.—In accordance with section 3 of the organic law of the survey, large collections of fossils, ores, rocks, and minerals were made, one set of which was deposited with the Wisconsin Academy of Sciences, Arts, and Letters, one with the State University, and one each to such of the incorporated colleges and normal schools as should make application for them before the beginning of the field work. Some 20.000 specimens are reported to have been thus destributed during 1879, the closing year of the survey. These were largely in the nature of fossils, the ores and lithological materials being reserved for future study.

The following acts relate to the publication and distribution of the reports:

An act relating to the preparation, publication, and distribution of the final report of the geological survey.

The people of the State of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. That in the preparation of the final report, the chief geologist be, and he is hereby, authorized to collate the general geology and the leading facts and principles relating to the material resources of the State, together with practical suggestions as to the methods of detecting and utilizing the same, so as to constitute the material for a volume suited to the wants of explorers, miners, landowners, and manufacturers, who use crude native products, and to the needs of the schools of the State and the masses of intelligent people who are not familiar with the principles of geology; said volume to be written in clear, plain language, with explanations of technical terms, and to be properly illustrated with maps and diagrams, and to be so arranged as to constitute a key to the most perfect understanding of the whole report.

SEC. 2. The annual reports for the years 1873, 1874, and 1875 are hereby placed in the hands of the chief geologist to be used in the preparation of his final report.

SEC. 3. The commissioners of public printing are hereby authorized and directed to procure the printing, under the supervision of the chief geologist, of 7,000 copies of the volume provided for by section 1 of this act, and of 2,500 copies of the complete report.

SEC. 4. The said commissioners are also hereby empowered to procure, on the best terms they can make, such plates, cuts, engraved stones, and other means of representation as may be necessary to properly illustrate the report; and they are directed to contract for the delivery, after the printing of the report, of such plates, cuts, engraved stones, and other means of illustration, to the State.

SEC. 5. The said commissioners are hereby further authorized to determine, with the advice of the chief geologist, the form in which the report shall be printed, and to make exception of the printing of said report in advertising for bids for the public printing, and in making contracts for the same, as provided for in chapter 243 of the General Laws of 1874, if in their judgment the nature of the publication makes it desirable to do so, and are empowered to make special contract for the printing of said report: *Provided,* They shall in no case pay a rate exceeding that paid the State printer: *And provided further,* That they shall not violate any existing contract.

SEC. 6. Each school district within the State shall be entitled to one copy of the volume provided for by section 1 of this act; each high school and incorporated academy to 6; each normal school and incorporated college, to 15; and the State University to 25 copies, respectively, of said volume. Each member of the legislature of 1876 and 1877, every officer of State, each judge of the supreme court, shall be entitled to two copies of the complete report. Each officer of the present senate and assembly, each incorporated college or academy, each normal school, each high school, each State charitable or penal institution, each person who has rendered assistance in the prosecution of the survey, each scientific society in the State, and each town or city library, established under the provisions of chapter 80 of the General Laws of 1872 shall be entitled to one complete copy. The State University, the Wisconsin Academy of Science, Arts, and Letters, the Historical Society, and the State library, shall each be entitled to 10 complete copies. The remaining copies shall be placed in the hands of the governor and chief geologist for distribution to public libraries, scientific men, learned societies, and colleges beyond the limits of the State, preference being given to those situated in the centers of capital in the United States and in Europe, and in such other ways as may best serve the objects of the survey.[1]

SEC. 7. There is hereby appropriated out of any money in the general fund in the State treasury not otherwise appropriated, a sum sufficient to carry out the purposes of this act, not exceeding $25,000; and it is further provided that not to exceed $12,000 shall be drawn during the current year.

SEC. 8. All acts and parts of acts in contravention of the provisions of this act are hereby repealed so far as they affect the provisions of this act.

SEC. 9. This act shall take effect and be in force from and after its passage and publication.

Approved March 6, 1876.

An act relating to the publication and sale of the reports of the geological survey, and amendatory of chapter 121 of the laws of Wisconsin of 1876.

The people of the State of Wisconsin, represented in senate and assembly, do enact as follows:

SECTION 1. Chapter 121 of the laws of Wisconsin of 1876 is hereby amended by adding the following sections:

SEC. 10. The commissioners of public printing are hereby authorized to procure the printing of 1,500 additional copies of the final report of the geological survey, including accompanying maps: *Provided*, The said commissioners of public printing shall in no case pay a greater price for presswork, folding, collating, stitching, and binding than is paid the State printer at the time of the passage of this act for similar work under the State printing contract: *And provided further*, That no greater price shall be paid for any other portion of the said work than was paid for similar work upon the publication of volume 2: *And provided further*, That there shall be no extra charge for composition, stereotyping, cuts, plates, engravings, or other material entering into the work of said additional volume ordered to be published by the provisions of this act. These copies shall be deposited with the superintendent of public property, who is hereby authorized to sell them to any citizen of this State at the cost price, including the expense of handling, the cost to be computed by the secretary of state, and to any person not a citizen of this State, at a fair price above cost to be fixed by the secretary of state. And it shall be the duty of the superintendent of public property to keep an accurate account of such sales, and to pay the amount realized therefrom into the State treasury at the end of each quarter, and the State treasurer shall report the aggregate amount of the same in his annual report. The commissioners of public printing are further authorized to use a limited portion of any net profits that may accrue from the sale of the reports to persons not citizens of the State, in advertising the same in appropriate publications, if it shall seem to them in the interest of the State to do so. The said additional copies shall be distributed only as specified in this section, except by authority of the legislature.

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[1] This clause was subsequently amended to read as follows:

SECTION 1. Section 6 of chapter 121 of the laws of Wisconsin for 1876 is hereby amended by inserting after the figures "1877," in the eighth line of the section, the words "and 1878," so that the sentence shall read as follows: Each member of the legislature of 1876 and 1877 and 1878, the governor, lieutenant governor, secretary of state, State treasurer, attorney general, superintendent of schools, and each judge of the supreme court, shall be entitled to two copies of the complete report.

SEC. 2. This act shall take effect and be in force from and after its passage.

Approved February 27, 1878.

SEC. 11. The commissioners of public printing are hereby further authorized to complete the publications of the final report, provided it shall not exceed four volumes in all, with the accompanying maps, and provided the same is done at the same rates for an equally good quality of work and material as in the case of the volume already published.

SEC. 12. The office and functions of the chief geologist are hereby continued in existence, and he is authorized to perform all the duties devolving upon the chief geologist, in carrying into execution the provisions of this act: *Provided*, That this section shall not be construed as authorizing any fixed or permanent salary.

SEC. 2. There is hereby appropriated out of any money in the general fund of the State treasury, not otherwise appropriated, a sum sufficient to carry out the purposes of this act.

SEC. 3. This act shall take effect and be in force from and after its passage.

Approved March 12, 1878.

APPENDIX 1.

SUMMARY OF PRINCIPAL ITEMS RELATING TO STATE SURVEYS.

In the following table an attempt has been made to summarize as accurately and succinctly as possible some of the more important facts given in the foregoing pages. Obviously, the items relating to expenditures have presented the greatest difficulty, and numerous explanations have been necessitated in the form of footnotes. It is worthy of note that while in some instances the appropriations have been, for the date and period involved, fairly generous the total amount is pitifully small when the purpose of the undertaking and results are considered.

Tabular statement giving dates, names of chief geologists, and expenses of all State surveys existing prior to 1900.

State.	Geologist.	Expense.
Alabama:		
1848–1856	M. Tuomey	[1] $15,000.00
1873–1900	E. Smith	115,500.00
Arkansas:		
1857–1860	D. D. Owen	16,400.00
1871–1873	W. F. Roberts	15,000.00
1873–1874	Haddock, Hazeldine, Syberg	17,386.00
1887–1895	J. C. Branner	[2] 120,000.00
California:		
1850	J. B. Trask	7,000.00
1860–1873	J. D. Whitney	258,600.00
1880–1900	State Mining Bureau	471,171.23
Connecticut: 1835–1842	Percival and Sheperd	5,000.00
Delaware: 1837–1838	J. C. Booth	3,000.00
Georgia:		
1840	J. R. Cotting	[3] 10,000.00
1874–1879	George Little	51,000.00
1889–1900	Spencer and Yates	[4] 96,000.00
Illinois: 1851–1900	Norwood and Worthen	[5] 303,521.00
Indiana:		
1837–1838	D. D. Owen	[6] 1,750.00
1859–1861	D. D. Owen and Richard Owen	5,000.00
1869–1878	E. T. Cox	[6] 66,000.00
1879–1884	J. Collett	[6] 25,505.00
1885–1887	M. Thompson	[6] 10,000.00
1888–1894	S. S. Gorby	[6] 42,000.00
1895–1900	W. S. Blatchley	[6] 38,000.00
Iowa:		
1855–1857	Hall and Whitney	[7] 15,000.00
1866–1870	C. A. White	[8] 44,000.00
1892–1900	S. Calvin	[6] 50,000.00
Kansas:		
1864	B. F. Mudge	[6] 3,500.00
1865	G. C. Swallow	[6] 7,500.00
1889–1900	State University	[6] 16,500.00
Kentucky:		
1838	W. W. Mather	1,000.00
1854–1863	D. D. Owen	55,000.00
1873–1893	Shaler and Proctor	228,900.00
Louisiana: 1869–70	E. Hilgard	3,000.00
Maine:		
1836–1839	C. T. Jackson	[9] 12,000.00
1861–1862	C. H. Hitchcock	[6] 6,000.00
Maryland:		
1833–1841	J. T. Ducatel	[6] 17,909.00
1896–1900	W. B. Clark	[6] 40,000.00

[1] No appropriation until 1854. Does not include publications. Includes publications and all expenses.
[2] Includes printing, engraving, binding, and office expenses.
[3] Amount of appropriations.
[4] Not including cost of publications.
[5] Includes expenses of Survey, Historical Library, and State Museum of Natural History.
[6] Not including cost of publications.
[7] Amount of appropriation. Includes $10,000 for publications.
[8] Includes cost of publications ($18,000.).
[9] $5,000 in 1836; $3,000 in 1837; the amount given for 1838 is an estimate.

Tabular statement giving dates, names of chief geologists, and expenses of all State surveys existing prior to 1900—Continued.

State.	Geologist.	Expense.
Massachusetts:		
1830–1833	Edw. Hitchcock	[1] 2,030.00
1837–1841	....do	[1] 2,500.00
Michigan:		
1837–1845	D. Houghton	47,829.03
1859–1870	A. Winchell	[2] 6,080.91
1871–1900	Rominger, Brooks, Pumpelly, Wright, Wadsworth, Hubbard, and Lane.	167,528.42
Minnesota:		
1864	A. Hanchett	2,000.00
1865	H. H. Eames and N. D. C. Taylor	[1] 2,000.00
1872–1888	N. H. Winchell	[3] 68,551.09
Mississippi: 1850–1860	Millington, Wailes, Harper, and Hilgard	[4] 17,445.00
Missouri.		
1853–1862	G. C. Swallow	[5] 95,200.00
1870–1871	A. D. Hager and Norwood	[5] 2,500.00
1872–1874	R. Pumpelly and G. C. Broadhead	[5] 72,000.00
1889–1900	Winslow, Keyes, and others	[5] 147,025.42
Nevada: 1866–1877	State mineralogist	[6] 57,942.68
New Hampshire:		
1839–1840	C. T. Jackson	[7] 9,051.15
1868–1878	C. H. Hitchcock	[8] 67,618.24
New Jersey:		
1833–1837	H. D. Rogers	[1] 5,000.00
1854–1856	W. Kitchell	[1] 36,902.69
1864–1900	George H. Cook and J. C. Smock	[9] 244,292.24
New York:		
1836–1887	Hall, Emmons, Vanuxem, Mather, and Hall	[10] 670,964.81
North Carolina:		
1824–1828	Olmsted and Mitchell	1,250.00
1852–1864	E. Emmons	[11] 58,611.60
1864–1882	W. C. Kerr	[12] 80,820.03
Ohio:		
1836–1841	W. W. Mather	[12] 16,700.00
1869–1885	J. S. Newberry and Orton	[13] 333,892.97
1889–1893	Edward Orton	4,000.00
Pennsylvania:		
1836–1842	H. D. Rogers	[14] 82,000.00
1874–1888	J. P. Lesley	[15] 643,000.00
Rhode Island: 1839–40	C. T. Jackson	2,000.00
South Carolina:		
1842–1846	E. Ruffin and M. Tuomey	11,632.78
1856–1858	O. M. Lieber	[16] 12,194.50
Tennessee:		
1831–1848	G. Troost	4,500.00
1848–1860	J. Safford	10,500.00
1871–1900	....do	[17] 5,000.00
Texas:		
1858–1859	B. F. Shumard and F. N. Moore	15,073.00
1873–1875	J. W. Glenn and S. B. Buckley	19,728.00
1888–1894	E. T. Dumble	[11] 178,000.00
Vermont:		
1845–1847	C. B. Adams	6,000.00
1856–1860	Edw. Hitchcock	[15] 4,000.00
1896–1900	George H. Perkins	[1] 6,000.00
Virginia: 1836–1841	W. B. Rogers	[1] 40,000.00
Wisconsin:		
1853–1856	Edw. Daniels and J. C. Percival	[1] 7,500.00
1857–1862	J. Hall and J. D. Whitney	[1] 36,000.00
1873–1879	Lapham, and Wight, and Chamberlin	[1] 62,000.00
		$5,558,006.79

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[1] Not including cost of publications.

[2] Is less than amount appropriated by upwards of $60,000.

[3] Expense of survey proper and general museum as given by Winchell, Bulletin No. 1, Geol. and Nat. Hist. Surv., Minnesota, 1889.

[4] Includes cost of publications.

[5] Includes cost of publications ($40,820).

[6] Estimates based on appropriations.

[7] Exclusive of publications.

[8] Includes $33,959.17 for publication of final report.

[9] Not including cost of publications ($216,569.73).

[10] Appropriations for salaries, printing (in part), collecting, drawings, etc., up to 1888.

[11] Including engraving and printing.

[12] Including engraving and printing in part.

[13] As given by Newberry, see footnote, p. 424.

[14] Including engraving and printing ($16,000).

[15] Not including engraving and printing. ;

[16] Including $3,194.50 for publications.

[17] Estimated; $300 a year for a part of the time.

APPENDIX 2.

THE NORTHERN TRANSCONTINENTAL SURVEY.[1]

The Northern Transcontinental Survey was originated by Henry Villard when he accepted the control of the great system of railroads on which Oregon, Washington Territory, Montana, Dakota, and, to a great extent, Minnesota were dependent for their growth. Trunk lines on still undetermined routes were to be built, the system extended, and tributary lines to be constructed. This large part of the United States, from which the system was to derive its life, was to a very great extent an unknown land as regards its capacity for production.

The object of the Northern Transcontinental Survey was to ascertain broadly the mineral, agricultural, and forest resources of this vast region. The personnel of the survey was selected for this purpose and the following divisions were established:

Mineral resources: George H. Eldridge, Bailey Willis, Bayard T. Putnam, geologists in charge.

Climate, rivers, and irrigation: E. S. Holden, in charge.

Agricultural: E. W. Hilgard, in charge.

Forests: C. S. Sargent, in charge.

Forage plants: W. M. Canby, in charge.

Laboratory: F. A. Gooch, in charge.

Topography: A. D. Wilson, in charge.

The division of mineral resources traced out the rock formations and studied the mineral resources, especially in coal and iron ores, and also paid attention to subterranean water supply and the question of artesian wells. It had charge of the work of finding and testing coal for the use of the roads, and was equipped with a diamond drill for testing in depth.

The division of climate, rivers, and irrigation was established to study climate; that is, of the great valleys and of the climatic zones of elevation. It established stations at points representing the local climates, at which there were observed temperature and rainfall and certain other important facts. This division also had charge of the work of gauging the streams and determining the relation between the prospective demand and supply of water for irrigation in the different valleys.

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[1] From manuscript by Raphael Pumpelly, Director.

The agricultural division determined the areas of the various soils and represented them on the map, according to a classification based on observation in the field of the conditions of the soils, the native vegetation, and on chemical and mechanical analyses.

The division of forests determined the distribution of the various trees, and had different forests examined by men well known for their experience in regard to timber and the manufacture of lumber. The object was to obtain such a general knowledge of the economic character of the forests as would be needed in order to settle many questions of general policy. Where it should be necessary, closer estimate of the amount of timber on each quarter section would be made independently. This division also paid attention to general questions of the planting and acclimation, and to questions relating to the forest policy of the roads.

The division of forage plants related especially to the plants which form the basis of the whole grazing industry, and of other questions relating to that business. This division was also charged with the duty of ascertaining from the experience of other countries the useful plants, either entirely new to us or of hardier varieties, which are adapted to cultivation in our different climatic areas.

In the laboratory were analyzed the large amount of samples collected in the field; and there also were carried on such experiments as were necessary to determine the commercial value of such useful materials as were discovered by the survey.

The division of topography had charge of the mapping of the more important portions of the region covered by the survey. It also had the duty of determining and representing the areas of land adapted to irrigation, and from an inspection of the maps it is practicable to determine in a broad way the possibility of large irrigation enterprises.

The object of the survey was essentially, by gathering systematically all the facts concerning the resources of the region, to obtain the data necessary to guide the companies in regard to building feeders, in regard to matters of policy in encouraging the starting of different industries, and in directing immigration to the proper points. It was also intended to furnish to the world such comprehensive information concerning the great Northwest and its resources as should forward a sound development of the country, and thus increase the prosperity of the companies under whose auspices the enterprise was conducted. To insure the gathering of these facts in such a manner as to make them of service the divisions were put under the direction of men whose names vouched for their value.

To execute the survey in the manner planned required the organized effort of a force working at a considerable expense. The result of this effort was the collection of an enormous number of facts, which would be almost useless unless properly digested and correlated, and represented in a graphic manner. The information obtained concerning this great area can be expressed only in very general terms without at least approximately accurate maps on which the facts observed would be clear to everybody. As such maps did not exist the survey was obliged to make them which was done to the extent of several thousand square miles.

The region with which the survey had to do presented itself to the economist in two aspects. First, as a producer of raw materials. It has immense forests on the western coast and in the interior mountain valleys, forests on which the whole United States may before long become dependent. The railroads of this corporation are destined to become the most important lumber-carrying roads in the world. It was evidently, therefore, important that the commercial character of these forests should be determined, and the data gathered for the framing of a forest policy. The mineral wealth of this region was known to be both varied and extensive, and there is little doubt that a properly conducted study of mineral resources would lead to the encouragement of many industries which might lie dormant in the absence of the information that was furnished by the survey. Nearly all of the region excepting the forest and the rugged mountains is adapted to grazing; vast areas to grazing only, others in part to grazing and in part to agriculture. It was important to have the data for determining upon what areas the small amount of possible agriculture should be discouraged in order to protect the naturally predominant grazing interest, and for what areas the opposite policy should be adopted.

The second aspect in which the region presents itself is as to its capacity under cultivation. While there are large areas of land which are always sufficiently watered at the right season by rain and dew, there are larger areas in which droughts occur more or less frequently and in which the possibility of irrigation would insure its agricultural value: and there is a far larger area in which the soils are of the higher and highest grades, on which the cereals can not, under existing climatic conditions, be cultivated without irrigation. Now this region is traversed by many rivers with many tributaries, some of them fed by spring and autumn rains, and others by the summer melting of the snow on the mountains. There is no physical question that is more intimately connected with the future and immediate prosperity of this great region than that of irrigation. The determining of the maximum and minimum amounts of water in the streams; the periods of flood; the areas where the climate renders irrigation necessary and where unnecessary; the areas in each valley of bottom and bench land adapted to irrigation, and the relation existing in each valley between the area needing irrigation; and the water supply and the times of different stages of water—these are the chief factors in the problem. And it seemed that there was no direction in which the survey could be of greater service, both to the roads and the country, than in that of determining the fundamental facts relating to the possibility of irrigation and artesian wells in this region.

The intention was to make the record of the results of the survey essentially cartographic; to show upon the maps in a general form all the physical facts that have an important bearing on the prosperity of that region.

Having this object in view from the beginning, the topographical survey represented the form of the surface by contour lines of 200 feet vertical distance. The maps show the form of the surface, the grades of the streams, the extent of the bottom and bench lands, and the extent of the uplands.

It was intended that one of these maps should show the minimum known volume of water, at high and low water, in the principal streams, and the seasons at which these stages occur; and the classified distribution of the soils and subsoils. This set was to exhibit the data needed to determine the practicability of irrigation and under drainage. On another set were to be shown the present climatic conditions according to natural or local subclimate areas. These were to show the rainfall and temperature by months, and the phenomena which condition the success or failure of different crops were to be mapped by areas and crop seasons. These maps were not necessarily to be based, as regards these conditioning phenomena, wholly on our short range of observations, for the reason that these are facts of general information, and traders, military officers, ranch men, and Indians all observe and remember for years the times of injurious frosts, of droughts, and the years of failure of the few local crops.

Another set of maps showed the distribution and relative abundance of the various and numerous forage plants, and the climatic facts conditioning success in stock grazing.

A fourth set to show the mineral resources. On these were to be represented the geological formations of the region, the outcroppings of coal and the areas underlaid by it; and as the survey was to test by drill and otherwise the character and thickness of the coal in the different fields, these facts would appear on the maps in a generalized form.

It was intended to carry the work on in such a manner that the results of each season would be finally represented on the maps during the ensuing winter.

The only connection of the survey with other institutions was through an accidental community of officers: Two of the officers, Professors Sargent and Hilgard, occupied chairs, respectively, in Harvard University and the University of California, while a third, Professor Holden, was the director of Washburn Observatory.

The survey was sustained by annual general appropriations and special allowances.

The accompanying table gives a list of the members of the survey corps and their salaries:

Members.	1881	1882	1883	1884
Raphael Pumpelly, director	$10,000	$10,000	$10,000	$10,000
Chas. E. Smith, bookkeeper	1,200	1,200	1,200	1,200
F. A. Gooch, chemist	1,100	1,500	3,000	3,000
Hermann Olm, section cutter	720	720	720	....
James Craig, janitor	500	500	600	....
J. W. Kennett, map copyist	900	900	900	900
Bayard T. Putnam, geologist	1,800	1,800	2,500	3,000
Chas. F. King, chemical assistant	600	....	....	....
Bailey Willis, geologist	1,800	1,800	2,500	3,000
W. T. Richmond, chemical assistant	....	900	....	....
Edward Whitfield, chemical assistant	....	900	1,200	1,200
Samuel Williston, private secretary	....	480	1,200	1,200
Geo. H. Eldridge, geologist	1,800	1,800	2,500	3,000
A. D. Wilson, topographer	....	3,000	3,500	3,500
Oscar E. Smith, clerk	....	480	550	550
Thos. R. Hill, topographical assistant	....	600	600	600
Frank Tweedy, topographical assistant	....	600	900	900
C. S. Sargent, salary of self and assistant and expenses, forestry department	....	5,000	5,000	5,000
Louis Neil, topographer	....	2,400	2,400	2,400
E. S. Holden, salary of self and assistant and expenses, climate and irrigation department	....	4,000	4,000	4,000
W. P. Dawley, laboratory assistant	....	600	750	750
W. M. Canby, salary of self and assistant and expenses	....	4,000	4,000	4,000
Richard Bliss, jr., librarian	....	1,000	1,000	1,000
E. W. Hilgard, agricultural department	....	2,500	2,500	2,500
T. J. Brandeger, field assistant	....	1,000	1,000	....
R. C. Templeman, field assistant	....	1,500	1,800	1,800
A. O. D. Taylor, chief disbursing agent	....	1,500	2,000	2,000
H. A. Hagen, entomologist	....	500	....	....
F. D. Owen, topographer	....	....	1,600	1,600
A. O. D. Taylor, jr., clerk	....	....	450	600
R. U. Goode, topographer	....	....	1,500	1,800
Edwd. C. Hall, grazing expert	....	....	1,200	....
J. Eliot Wolff, geologist	....	1,200	1,200	1,200
J. R. Williston, field assistant	....	300	300	....
W. S. Fritz, in charge of diamond drill	....	....	1,800	....
Geo. W. Driver, foreman in coal explorations	....	1,500	1,500	....
R. E. Finlay, surveyor	....	....	1,800	....
Josiah Pierce, jr., topographical assistant	....	....	300	300
W. M. Davis, geologist	....	....	2,400	....
H. B. Ayres, field assistant	....	....	600	....
Waldermar Lindgren, geologist	....	....	750	750
F. J. Knight, topographical assistant	....	....	1,500	1,500

Appointments were made by the director. Efficiency and success were the governing principles in regard to promotion. The director made annual reconnoissances with reference to laying out the work of the following. Each large area to be taken in hand was occupied by a topographical party working from an independent base line. Each topographical party was accompanied by one or more field assistants, whose duty it was: First, to gauge the streams and take notes with reference to irrigable areas and measure cross sections of such areas; second, to collect samples of the soils and grasses and specimens of the trees.

The following year a geological party equipped with rapid-process copies of the topographical map, made a special exploration of the area for coal-bearing districts. The coal beds were explored by pits, trenches, or tunnels under cover; differential samples were taken and these were sent to the home office and analyzed. In order to locate on the existing or prospective map the position of field observations the observers were provided with a light, specially constructed dioptic compass which revolved on a graduated circle and could be read more closely than by the needle. Bearings taken to several prominent points served to approximately fix the position of the observation to be recorded.

No museum was established.

The total expenditure for the survey during the three years (two years of field work) of its existence was $398,940. Of this amount more than a third was spent in the special exploration of the coal fields, in digging and boring. The publications were map bulletins.

Topographical department: Bulletin No. 1, A. D. Wilson, in charge. Map of the Yakima Region, Washington Territory; 2 sheets; A. D. Wilson and R. U. Goode. Map of the Colville region, Washington Territory; 1 sheet; Louis Nell. Map of the Judith Basin, Montana Territory; 2 sheets; A. D. Wilson. Map of the Crazy Mountains, Montana Territory; 1 sheet; A. D. Wilson.

Agricultural department: Bulletin No. 1, E. W. Hilgard, in charge. Preliminary agricultural map of the Yakima region; 2 sheets. Preliminary agricultural map of the Colville region; 1 sheet.

Forestry department: Bulletin No. 1, C. S. Sargent, in charge. Forest map of the Yakima region. The Cretaceous bituminous coals of Montana and Washington Territories. Topographical map of central Montana; 5 sheets. Geological map of central Montana; 5 sheets.

The editions were limited to 600 copies and were distributed chiefly to libraries and societies.

The greater part of the results remains unpublished.

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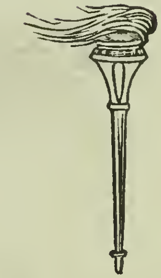

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